PHYSIOLOGY

TURNER

To Mr. Dickinson,
Compliments of the
Author.

THE PHYSIOLOGY OF THE HUMAN BODY AND HYGIENE

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ILLUSTRATED

FOR MEDICAL SCHOOLS AND COLLEGE CLASSES GENERALLY

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THIS VOLUME IS RESPECTFULLY DEDICATED TO

PROF. S. C. CHEW,

MY LEARNED TEACHER AND KIND FRIEND

PREFACE.

Human Physiology and Hygiene, in clear and concise language, is presented in this book so far as possible. The author has striven to make facts and theories comprehensible to school and university students, and also to readers generally.

Descriptive Anatomy is, we think, most necessary in the study of Physiology, and, briefly, we have tried to describe each tissue and organ before giving its function.

First, we have aimed to study and to teach the important structures of the body; and second, we have explained the varied functions and the individual functions of the parts, both generally and specially.

We think and hope that this work may fill a gap found in physiological studies of the times. Most books of today are too brief or too scientific for our medical students with limited time and laboratory instruction.

The writer has avoided the long discussions of unsettled points, but has stated briefly the salient facts deducted therefrom. Many dissections and experiments upon more than 280 animals have been made to simplify the facts, without becoming too scientific. Illustrations are used when thought feasible.

Models can be used to great advantage in studying this work; also plates, enlarged, are beneficial.

The author has carefully examined all the best works and journals at his convenient reach, and has used such material freely, yet giving credit to each author thus consulted.

Each plate, when possible to find out, is duly credited and kindly acknowledged in print, and in some cases in person.

Testut's beautiful plates have been freely used, and those of many others, which have been placed so as to arrange the study more simply and pleasing.

For kind assistance and advice the author takes great pleasure in acknowledging the assistance freely given him by Drs. David Culbreth, Randolph Winslow, S. C. Chew, W. H. Howell and F. T. Miles, all of whom have been his esteemed teachers and friends. Having been Dr. Miles' assistant two years, the author gained valuable information from his many lectures and interesting experiments, for which he wishes to thank him at this time.

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CHAPTER I.

COMPOSITION OF THE HUMAN BODY.

Definitions. The structure and composition of the human body, in brief, must be exactly examined; and the forms and mode of growth of its component parts outlined and closely studied. When we compare these forms, etc., to the lower animals, it is then called *comparative anatomy*. If we more especially study the living body as an organism presenting concise properties and performing certain actions, or functions, these investigations lead us to discover the *duty* of each organ or structure. This, then, is *Physiology*, or the science of healthy action of each part of the body. *Hygiene* is closely allied with Physiology; it is concerned with the conditions which are favorable to the healthy action of the different part of the body; while the diseased action and structure of the body form the subject of the science of *Pathology*.

The human body is the most complete and perfect specimen of the Creator's handiwork. It is true that some animals, such as the fox, the dog and numerous others, may have keener senses specially intensified, as cunning and the sense of smell, respectively; but man stands out pre-eminently as the acme, the climax, the supremest possibility of art or nature. Man stands apart and above all other animals, and to examine his structure and the uses of each individual part, how to guard it from serious injury, and to keep it in a physiological or healthy state, is our aim in writing this book.

We divide our departments of investigating knowledge into the science of Human Physiology and the art of Hygiene.

Physiology, then, to repeat, treats of the action or uses of the various vital parts of the body. Every living thing, vegetable or animal, therefore, has a Physiology. Human Physiology treats of the uses of the many parts of the human being; and Comparative Physiology treats of the lower animals compared to the higher order, or man himself. Physiology is only Hygiene, artfully used for practical preservation of our health. It teaches us how to avoid a large number of diseases; how to prevent many accidents which could seriously affect our bodies. Our mental powers and physical strength are markedly increased by healthy, or physiological, exercise. Why should we not know and fully realize the importance of our structure and the function of each individual part of our body? No higher type lives than the human type of structure.

We learn the Physiology of man by comparing the structure of plant life, its circulation, its sensitiveness and its absorption powers. The lower animals are dissected and experimented upon for man's profit and learning; their organs are also especially examined, so also their extremities, as the frog's foot beautifully illustrates a simple method of observing the circulation of the blood. In frogs and in alligators we remove parts of the brain and then watch the results of the action of the remaining parts. By vivisection, or laying bare of some of the organs of animals, we can thus watch and record certain vital processes which otherwise could never be understood. Frequently we learn important facts from men who, from some accident, expose some important organs, which demonstrate many truths otherwise almost impossible to research and experiment.

The microscope, the superhuman aid to our eyesight, helps wonderfully to magnify the small objects we experiment with, and closely examine. Indeed, the microscope is our first and best aid to close physiological study of the organs, and the necessary constituents of our bodies. Vitality, or life, is *a* microcosm in itself. We cannot tell what life is, but we only try and explain its results. We do know, however, that each part of the body seems to be in sympathy with every other part. If we wish to *see* well we look down, stop breathing and listen, etc. Some organs are always

working, while others are allowed to rest temporarily without injury to the body. We have few superfluous structures in our bodies. The Vermiform Appendix is supposed to be one; but recently an eminent surgeon said this organ supplied a lubricant for the large intestines. The suprarenal capsules, thyroid gland, carotid gland and other ductless glands were supposed to be useless, but now they are considered most important factors in the body structure. Nothing, then is useless.

CHAPTER II.

THE FRAMEWORK OF THE BODY AND ITS TISSUES.

The bones form the frame which sustains the human body. The ligaments hold the bones together, and the muscles act as pulleys and move the bones by flexing, extending, etc. The organs are those vital parts on which the processes of life depend, and being of a soft and delicate structure, need protection, or else they would be injured or destroyed by the violent movement of the body. Bones give this protection, and at the same time act as powerful levers. The more delicate the organ, the greater the bony shield by nature's device. The brain, being soft and needing protection from shock, is completely enclosed by a spherical box of bone; the lungs are surrounded by our "chest" of bone and muscle, allowing free motion, but protection as well; the eye is sheltered from injury within the deep fossa of bone, yet it is near the surface of the body and is allowed free motion. Few things are more useful than bones. They help to give contour to our bodies, and by the muscular attachments thereto round out rough and sharp curves or outlines and help to make comely appearances to all. They hold the soft parts in their places properly, and motion is almost wholly caused by muscular exercise upon bony surfaces.

It has been said "that the human mind, which can survey the heavens and calculate the motion and density of the stars, finds itself confounded when, returning from these distant objects, it enters its own dwelling place—the body." Man's own organization is still among those mysteries of nature which he is least able to penetrate. In all ages he has sought to know himself. He has studied the relations between his own existence and that of the world.

Tissues. Examined merely from the outside, our Bodies present a considerable variety and complexity of structure. Head, neck, trunk and limbs we easily recognize: so, also, can we recognize smaller parts, as the eye, nose, ears,

arm, hand, leg and foot. We can even from slight examination, tell the different materials entering into the formation of the larger parts. Skin, nails and teeth are composed of different substances obviously; by pressure we recognize harder and softer substances; and if we cut a finger we can see a liquid constituent flowing from the injured part. By dissecting a body carefully our idea of mystery deepens as we reach the internal organs and note their complexity and marvelous structure. These materials used for building organs and general anatomical parts are called *tissues,* and the arrangement and character of these tissues in our numerous and intricate organs is the study of Histology, or Minute Anatomy, learned by the use of the microscope. If, like the poet, we compare the Body to a house, we may still further liken the tissues to the bricks, stone, mortar, wood, iron, glass, etc., used in building; the walls and floors, stairs and windows, etc., could then answer to anatomical organs in general.

Position of Man Zoologically. Darwin points out that man was primarily intended *for* a four-legged animal on account of the arrangement of the intestine in the horse, compared to the arrangement of man's intestine, on account of his upright, erect carriage; in the one (the horse) we never have—piles; in the other (the man) we have—piles. He claims if man were to travel in his natural state—on all fours—piles would be unknown.

We do resemble the bodies of many other animals; head, neck, trunk and extremities, with various smaller parts entering into their composition, are not unlike those identical parts of lower animals. Our bodies, upon closer study and comparison to other animals, prove conclusively that these resemblances are not superficial only, but that our body-structure may be in common with the body structure of many other creatures. By closer study we can see a greater resemblance between the Human Body and the bodies of ordinary four-footed animals than between it and the bodies of birds, reptiles, fishes, etc. Man, then, zoologically, belongs to the group of Mammalia, which includes all animals in which the female suckles the young. Linnaeus includes man with the monkeys and apes in one subdivision of the Mammalia.

known as the Primates. Man is mentally far superior to any other animal, but this is no reason of objection to such classification, for zoological groups are defined by anatomical and not by physiological characteristics. Mental traits are rare phenomena of function, not of anatomical arrangement of tissues. Man, then, walks erect; most all other animals walk on all fours; some few special apes adopt intermediate positions, so we have to adopt terms suitable to precise meaning of anterior and posterior of an animal. The head end is always anterior, and the opposite end posterior, whatever the natural position of the animal; the belly side is called ventral and the opposite side as dorsal; right and left are not difficult problems. The nearest end of a limb to the trunk is spoken of as proximal with reference to the other, or *distal* end. The words *upper* and *lower* may be readily understood when applied to the natural position of the animal. We find that man's own class, the Mammal, differs very widely in its broad structural plan from the groups including sea anemones, insects, oysters, etc., but is similar in many points with the groups of fishes, reptiles and birds. These, then, with the amphibious, are placed with man in one great classification of the animal kingdom, the *Vertebrate.* The anatomical features or characteristics of all vertebrate animals is the presence in the trunk of the body of two cavities, a dorsal and ventral, separated by a solid septum, and in the adults of nearly all vertebrate animals a hard, bony central column or axis, called the *spine,* or *backbone,* develops in this partition or septum, and forms a support in the centre of the body of great mobility and strength. The thoracic cavity continues on up through the neck (if the animal has a neck) into the head, and there spreads out into the animal's brain cavity. The ventral cavity reaches only so far as the trunk's limits. It contains the main organs of the circulation of blood and of the respiratory organs, respectively, the heart and large vessels, and the lungs and bronchial tubes and wind pipe, or trachea. Often this cavity is called the *pulmonary* cavity or the *haemal* cavity. Upon the ventral side, or anterior side of the head, is the *mouth opening,* which leads into a long tube, the *alimentary canal;* this canal passes down through the neck and trunk and opens again on the

outside at the posterior part of the body. This canal passes then through the ventral cavity.

The Mammalia. In the mammalia, the ventral cavity is divided; in many other vertebrate animals it is not divided. A musculo-membranous transverse partition, called the *midriff,* or *diaphragm,* separates it into a *chest* or *thoracic* cavity, and an *abdominal* cavity. Any tube or structure passing from one cavity to the other must pass through this diaphragm, or partition. The abdominal cavity is specially concerned with the alimentary canal and its accessory organs of digestion, as the stomach, the liver, the pancreas, the spleen and the intestines. Other important organs are the right and left kidneys.

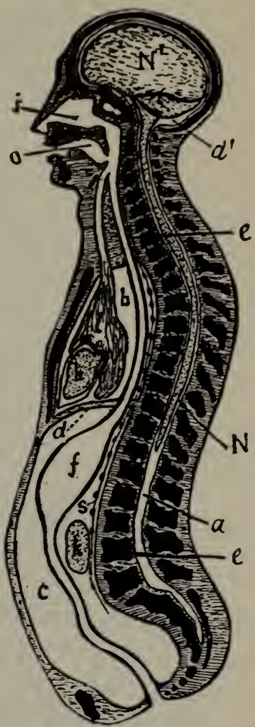

FIG. 1.—Diagrammatic longitudinal section of the body. *a*, the neural tube, with its upper enlargement in the skull cavity at *a*; *N*, the spinal cord; *N'* the brain; *ee*, vertebræ forming the solid partition between the dorsal and ventral cavities; *b*, the pleural and *c*, the abdominal divisions of the ventral cavity, separated from one another by the diaphragm, *d*; *i*, the nasal and *o*, the mouth chamber, opening behind into the pharynx, from which one tube leads to the lungs, *l*, and another to the stomach, *f*; *h*, the heart; *k*, a kidney; *s*, the sympathetic nervous chain. From the stomach, *f*, the intestinal tube leads through the abdominal cavity to the posterior opening of the alimentary canal.

In the dorsal or neural cavity we find the spinal cord and the brain, the latter occupying the enlargement in the head. The two, brain and spinal cord together, form the *cerebro-spinal nervous centre.* We also have in addition to this a large number of small nerve centres, united together by tiny connecting cords, which also connect with the cerebro-spinal centre, and with their offshoots forming the *sympathetic nervous system.*

Smooth, moist *serous membranes* line the walls of the three main cavities. That lining the dorsal or posterior cavity is the *arachroid;* that lining the chest the *pleura;* that lining the ab-

dominal cavity the *peritoneum;* hence, this cavity is sometimes called the peritoneal cavity. These walls are covered externally by the *skin,* which is composed of two layers, an outer scaly or horny layer, called the *epidermis,* which is constantly being shed on the surface and renewed from below; and a deeper layer, called the *dermis,* which contains blood vessels, while the other or epidermic layer does not contain blood.

Bones, muscles and numerous other structures are found between the skin and the lining serous membranes, which we shall have to study separately later. All air passages and food passages, as the windpipe and lungs and alimentary canal, are lined by soft and moist prolongations of the skin, known as *mucous membranes.* The structure of these is similar to that of the skin, except that the superficial bloodless one is named *epithelium,* and the deeper one the *corium.*

The Limbs. The limbs have no such cavity arrangements as the trunk, etc. They have an axis, sometimes two, which are *bones* surrounded closely by soft parts, vessels, nerves, but principally muscles; and the whole is then enveloped in skin. The only cavities in the limbs are small tubes, which are either filled during life with *blood* or a watery-looking fluid called *lymph.* These tubes, however, are found not only in the limbs, but all over the body, filled with blood and lymph, respectively.

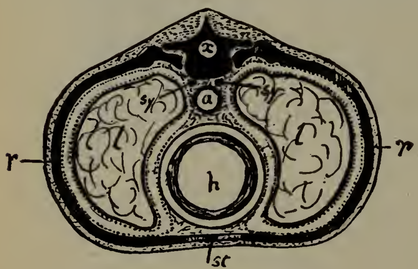

FIG. 2.

A diagrammatic section across the Body in the chest region. *x,* the dorsal tube, which contains the spinal cord; the black mass surrounding it is a vertebra; *a,* the gullet, a part of the alimentary canal; *h,* the heart; *sy,* sympathetic nervous system; *ll,* lungs; the dotted lines around them are the pleuræ; *rr,* ribs; *st,* the breastbone.

Composition of the Body. Chemical and Physical.—We have seen a number of substances of which the body is composed, and there are still more to be studied by the aid of *chemical analysis* and examination. There are *sixteen elements* known to chemists which are found in the structure of

the human body. These are carbon, hydrogen, nitrogen, oxygen, sulphur, phosphorous, chlorine, fluorine, silicon, sodium, potassium, lithium, colcium, magnesium, iron and manganese. Copper and lead have been found in small quantities; however, they are considered accidental, if present. These elements are usually found in the body *combined*. *Oxygen*, in small quantity, is found dissolved in the blood; it is also found in the cavities of the lungs, and alimentary canal, being that from the inspired air or swallowed by the injection of food and saliva. Nitrogen has been found uncombined in the lungs and alimentary canal, and, in very small quantity, we find nitrogen in the blood. Free hydrogen has been found in the area of great fermentative processes in the duodenum and jejunum; active fermentation of food, causing its evolution.

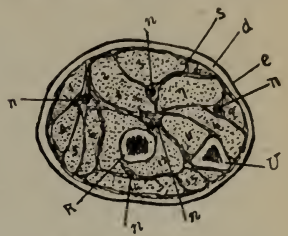

FIG. 3.-A section across the forearm a short distance below the elbow-joint. *R* and *U*, its two supporting bones, the radius and ulna; *e*, the epidermis, and *d* the dermis of the skin; the latter is continuous below with bands of connective tissue, *s*, which penetrate between and into the muscles, which are indicated by numbers; *n*, *n*, nerves and vessels.

It is extremely difficult to tell much, chemically, about the body tissues because we cannot examine exactly, without breaking down the more complex forms of living matter; therefore, we are usually left with the debris, or ashes, to examine. We do know quite accurately the compounds which enter the body as food, and what finally leaves it, as waste; but the *intermediate* conditions of these elements while *in* the Body, we know very little, and especially little do we know about their state of combination while in the body as *solid tissue*. *Living matter* is in a constant state of chemical transformation in its material, and this is inseparably connected (and must be) with its functions. Chemical study of the Body, then, necessarily and naturally leads us to physiological problems of the highest order.

CHAPTER III.

BODY TISSUES DIFFERENTIATED AND PHYSIOLOGICAL DIVISIONS.

Development. A single nucleated cell marks the commencement of the individual existence of every Human Body. This *cell,* the *ovum,* divides or *segments,* and gives rise to a mass consisting of a number of similar units, and which are known as the *morula* or *mulberry mass.* No organs are recognizable, nor are any tissues entering into the Body structure distinguishable at this period of development.

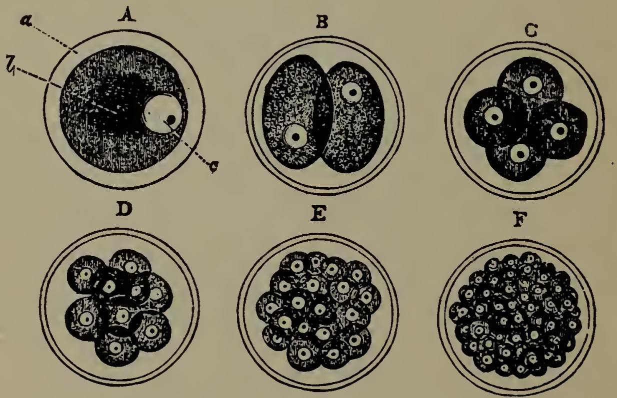

FIG. 4.—A, an ovus; B to E, successive stages in its segmentation until the *morula,* F, is produced.

In a brief period the *morula* increases in size by division and growth of its cells, but at an early stage of its existence *new processes* occur and these ultimately give rise to the *complex* adult body with its varied and many tissues and organs. Cells, formed in groups, which cease to grow and multiply like their parents, begin to act and grow in a most peculiar way, different entirely from the parent cell growth. After changes of this kind occur more and more marked, a varied whole tissue or organ forms with its individual com-

plexity, from its primary simple beginning; this is called *development,* a highly scientific study. And the process itself, having separated or specialized from the common mass of mother-cells, is known as the *differentiation of the tissues.* In the final aggregate of cells we find, not an independent collection of living things, but a *single human being,* in which each and every tissue and organ, while maintaining its own life, proper, at the same time performs duties for the good and co-operation of the whole Body.

In brief, a single *compound individual* is built up by the union of a number of co-operating simple cells, subordinated and working independently, yet presided over by the marvelously constructed whole.

THE DIVISION OF LABOR, PHYSIOLOGICALLY.

The Physiological properties, originally exhibited by all the cells, finally, are distributed between the different modified cells which form the tissues and organs of the perfect developed Human Body, just as labor is distributed in a small community—the day workman and the skilled artist and draftsman, all working, separately and independently, yet harmoniously and systematically for the whole population. Specialists among *men* means specialists among *cells,* for cells must become, *first, specialized,* before they can produce special tissues, which are usually found predominant in men-specialists. By a subdivision of labor in advanced towns a man becomes more proficient in his line, if it be bootmaking, or shipbuilding; naturally he will make better boots and more of them than a neighbor who not only makes boots, but also tries to build ships. Tools often used become bright and easily manipulated. For the production of, or building of a ship, the sailmaker knows nothing about the ceiling or keel; consequently we need and must have specialists in trade—artisans of rare skill. So with our body as a whole, we *need* and *have* special cells for special functions; these in turn form specially adapted *tissues.*

Tissues are for the distribution of employment, just as organs are for certain varied functions. The muscles for one purpose, the bones for another and the lungs for another,

till we exhaust the Human Body in our classification. We classify each structure according to its most distinctive property.

Undifferentiated Tissues are those found in all parts of the body, not specialized for the use of the *liver* or *heart,* but *common laborers* for any part of our anatomy. Among this class are the lymph corpuscles and the blood corpuscles, not only found *within* the blood vessels, but *without,* or all over the body.

Supporting Tissues, such as bone, cartilage and connective tissue generally, including the *white fibrous* or *inelastic,* and the *yellow* or *elastic* connective tissue. The mechanical purpose of the Human Body is in the systematic utility of these tissues, the bones and cartilages being for the express function of a framework, and support, as well as protection to the soft parts. The *connective* tissue links the various bones and cartilages together, forms investing membranes around numerous organs, and also we find a network or web of this connective tissue entering the structure proper of an organ to support the cells found in their minute formation. All these tissues are primarily to resist pressure and strains. No connective tissue is supposed to have irritability or contractibility; these functions are for the *higher* order of cell tissue, as brain cells, etc.

For our purposes in mechanical Physiology, we find even the study of *organs* added to that of the *separated tissues* does not exhaust our stupendous body analysis. We often have several *organs* and *tissues* arranged so that they work harmoniously together to attain some vital and most important end. Our circulatory apparatus, for clearness, illustrates this fact, for the heart, arteries, capillaries and veins act together for one great system and function of blood circulation and absorption processes. Different *systems* are spoken of in Anatomy and Physiology, such as the numerous muscles are grouped as the *muscular system,* the bones as the *osseous system,* and so on over the body. *System,* however, usually refers us to Anatomy study, while *apparatus* signifies most frequently Physiological research and application of uses.

All these *systems* and *apparatuses*, however named, which combine to form the Human Body in its marvelous compactness and mysterious structure and functions, such as the Circulatory, Digestive, Respiratory, Secretory, Osseous and other apparatuses, are *presided* over and wonderfully *controlled* by the system which we call the *nervous* system. In brief, we have found that *cells* form *tissues,* whether ordinary or special; that the tissues form the *organs* proper, and that the organs and tissues form the Body.

CHAPTER IV.

THE SKELETON.

The Osseous System is the bony system, forming the framework of the body. *Os* is from the Latin, meaning a "bone." This system is for protection as well as support of the softer tissues and organs. But for this bony protection the slightest violence would injure and often destroy these delicately formed members of our body. These bones are elastic, yet have great strength and power of resistance from external pressure. Nature guards completely a delicate organ, such as the brain or spinal cord, by throwing a circle of bony tissue on all sides to prevent shock and disturbance from the external world. In man, the bony tissue is found on the interior of the body between the mucous membrane and the skin. These are rounded off and finished by the cartilages. This is called *endoskeleton* structure or deeper than the skin development.

We find in clams, scales of fishes, the horny plates of a turtle, the hard, bony protection of an armadillo, and in the feathers of birds, the exoskeleton structure development for their protection and partial support. *Connective tissues* in the shape of tough bands or ligaments tie the bones and cartilages together firmly, and also changes its structure somewhat and pervades the whole Body, running through organs and muscles and found generally where needed as subsidiary. It has been called the skeleton of the tissues over the Body.

Articulations prevent our rigidity of bones, which necessarily would be stiff and immovable but for these movable attachments. The bones, then, to allow mobility are made into many sizes and shapes, and these different pieces of bone are joined together by these joints. If we lacked these joints we would not be able to eat or move a hand or foot. The number of bones in the adult is 200, exclusive of the teeth, the wormian bones and the ossicles of the ears.

To serve our many and different purposes bones must be of irregular form and shape. Thus we have long, short,

flat and mixed bones, to adapt themselves to the different functions of the Body economy.

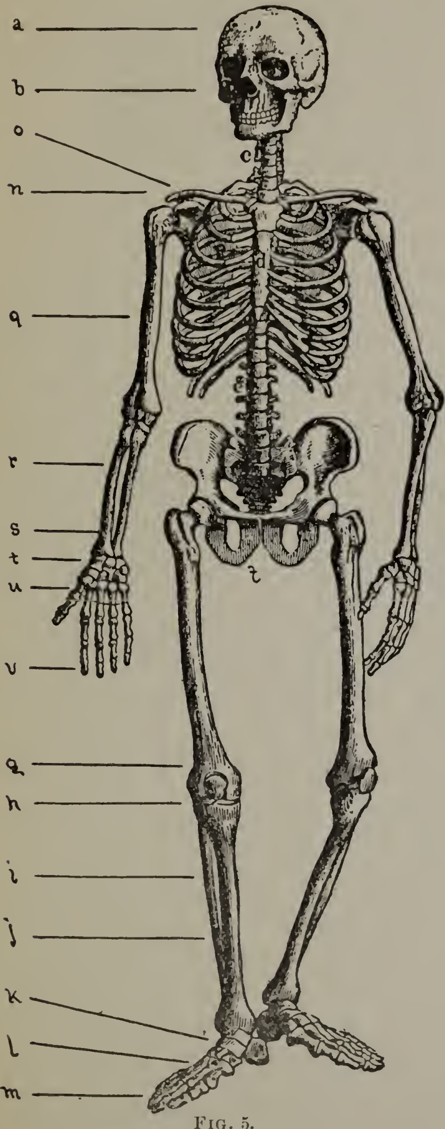

FIG. 5.

FIG. 6.

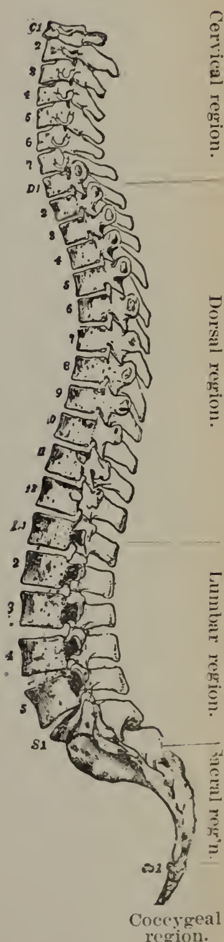

FIG. 5.—The bony and cartilaginous skeleton. *a*, cranium; *b*, face; *c*, neck; *d*, sternum; *e*, spine; *f*, pelvis; *g*, femur; *h*, patella; *i*, tibia; *j*, fibula; *k*, tarsus; *l*, meta tarsus (2d); *m*, phalanges; *n*, clavicle; *o*, scapula; *p*, thorax; *q*, humerus; *r*, radius; *s*, ulna; *t*, carpus; *u*, meta carpus; *v*, phalanges.
FIG. 6.—Side view of the spinal column.

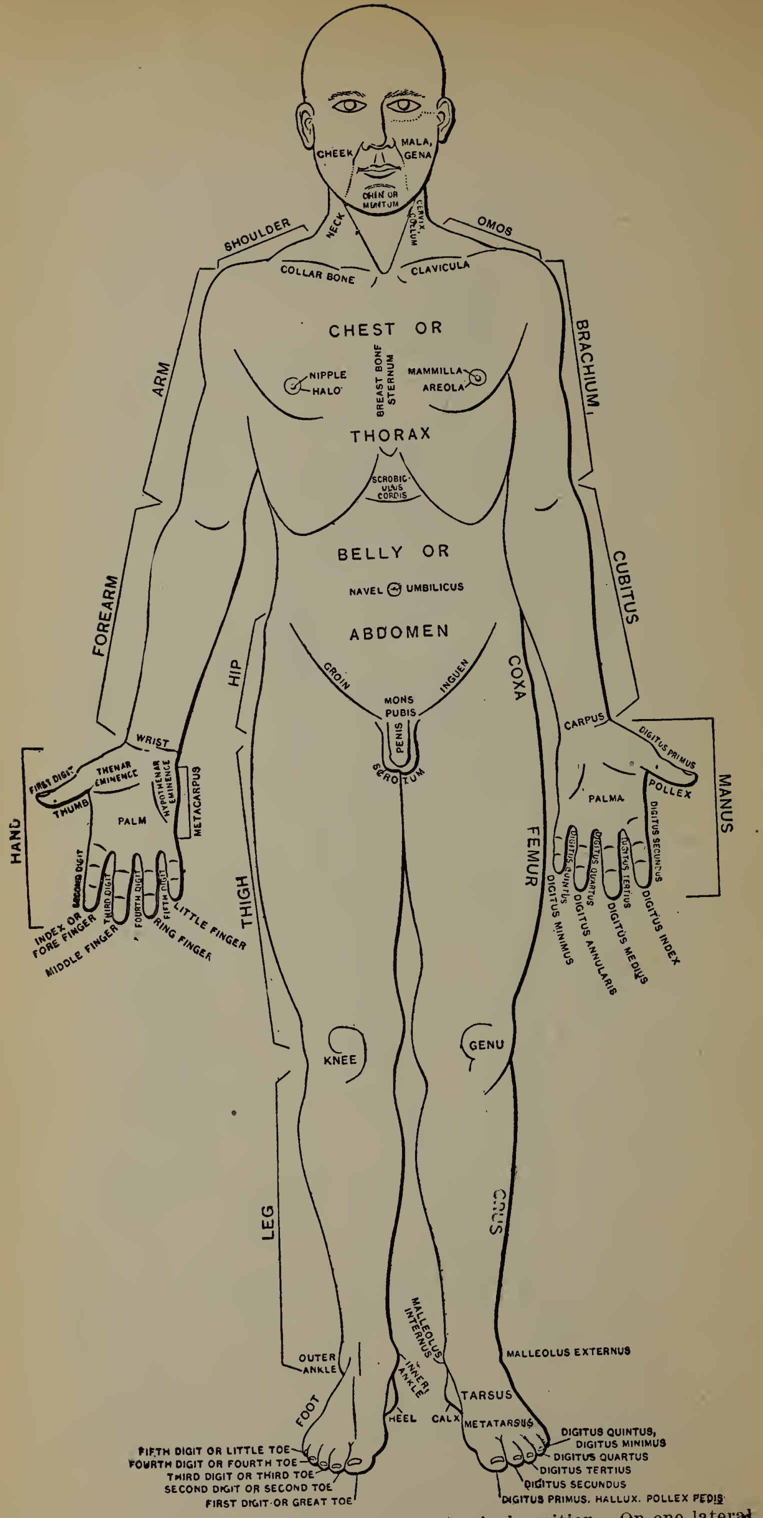

FIG. 7.—Front view of a man in the anatomical position. On one lateral half the parts are labelled in English, on the other in Latin. (F. H. G.)

The Composition of Bone. Usually the bones are arranged in pairs, one for each side of the body. In order to have *elasticity* and *hardness* at the same time in bones, we must have the structure thereof composed of those *animal* or organic ingredients which produce *elasticity,* also the *earthy* ingredients which produce *hardness.* To get the earthy material out of bone we place it in a solution of Muriatic Acid, 1 part to 5 parts of water, and in a few hours we have the *shape* of the bone left, but it can be bent and tied into a knot if it is a rib thus treated. Now, if we place another rib in the fire and burn it for a few hours, we have the same shape left, but when we try to bend it, it crumbles and turns to ashes. In short, the first bone lost its *earthy* or *hard* property by soaking in a solution, and the second bone lost its animal or elastic properties by burning or calcination. Both blended together make a hard bone, and also an elastic bone, to support the weight of the body, yet elastic enough to protect the bone if external violence is used. If these properties are not rightly blended in bone development we could readily have a bowed-leg or a too stiff limb; the young have easily bendable bones, the old have easily breakable bones. A broken bone in the youth knits or unites very quickly, while a broken bone in the old man sometimes fails to unite, or may be a long time uniting under the best circumstances. This plainly indicates the decline of active exertion. Bone has a most remarkable power to resist decay, and the teeth, a kind of bone, can resist the decay longer than ordinary bone. Teeth have been dredged up from the sea when no other part of the body could be found. The bones, then, differ at different stages of man's life. In the disease called *"rickets"* we find only among poorly-fed children of Europe, but rare in our country. A strong, healthy man will have large and dense bones, while in weak men and women and idiots we will find small and light bones. Bones need exercise as much and as regularly as muscles do. Disuse a bone by paralysis, and not only the muscles shrivel, but the *bone* also gets smaller and lighter. Fossil bones deposited in the ground long before man's presence on earth have been found to exhibit a large amount of cartilage. Cambridge has a

mastodon whose jaw yielded 40% of animal matter; some say, enough to make a good glue. Bone is reckoned as twice the strength of oak.

FIG. 8.—Human rib which has been deprived of its earthy matter and tied in a knot. (Dalton).

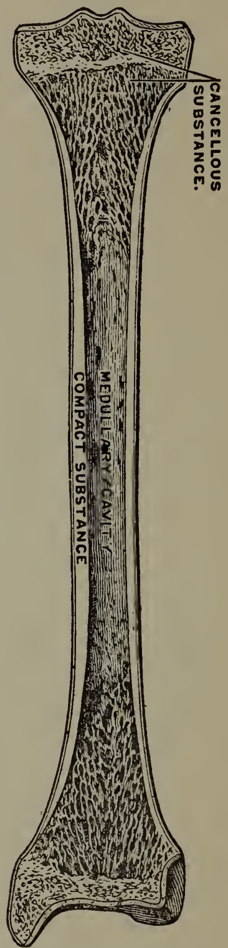

FIG. 9.—Vertical section of a long bone. (Testut).

The Physical and Minute Structure of Bone. In the bird, and especially the Humming Bird, we find its tiny bones are *hollow* and filled with *warm air,* to buoy it up; thus, the muscles are not required to act so vigorously in keeping the little fellow on its wing for half a day. With the Albatross the same. But when we consider the Whale, or the Sea Lion,

or any large aquatic creature, we find a vast difference in its structure. Nature has, indeed, economized by supplying these animals with *solid* bones, to help keep them below the water's surface *without* muscular effort. They breathe through the water, and only do they come to the surface at intervals—the Whale to feed and the Sea Lion to breathe. So with the porpoise and numerous others.

With man we find a happy medium. We neither wish to fly, like a bird; nor do we wish to swim, like the fish; but we have our bones so formed that we can try both without much effort. Of course, we cannot fly, but we can jump, and balance our bodies in many styles with ease; and we can dive and swim with great comfort, if necessary, and practice has been sufficiently regular. So we have partly *hollow* and partly *solid* bones in our structure, both properties being to afford lightness as well as great strength and enduring powers. The *exterior* is *compact,* and its *interior spongy* bone. And we find in a section of long bone a large canal running through its centre, which is filled with marrow in the living bone. In proportion to its weight, a hollow bone is stronger and gives more space on its exterior for the attachment of ligaments and muscles than a bone of the same weight, but *solid* instead of hollow. This is why we find most bones hollow; so, also, we find no bone in the body *straight.* We need curves, called "beauty lines" for our

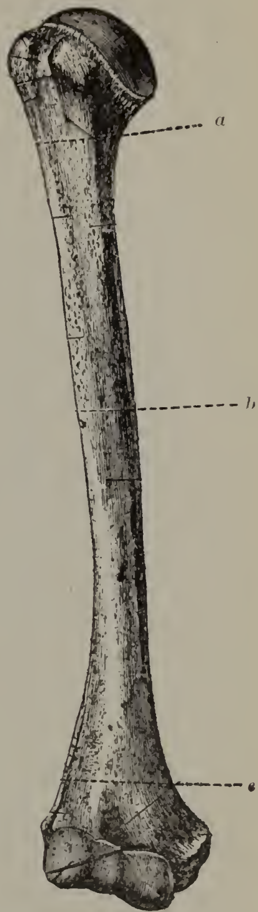

Fig. 10.—The Humerus, showing articular extremities, shaft and other points of a long bone: *a*, upper extremity; *b*, shaft; *c*, lower extremity.

many and peculiar motions. On examination of a cross section of bone with a microscope, we find marvelously arranged small canals, about which are thin plates of bone tissue, small boat-shaped spaces, reaching toward the primary canal above mentioned by a narrow gutter, through which pass living little arms, parts of the cell-like structure found in the little boat-shaped spaces surrounding the canal. So we see that bone is not such a solid structure as one would imagine from a casual inspection, for the magnifying glass reveals the fact that it is permeated with large and small spaces. There are three important cavities of the skeleton when the whole number of our bones are joined together symmetrically. The first, is the *skull,* made to enclose and protect the *brain;* the second is the *chest,* formed for the protection of the *lungs,* the *heart* and their immediate *connections* and *surrounding* membranes; the third is the *pelvis,* or basin to hold important intestinal coils and to afford protection to the important organs in females and males. The *chest* and *pelvis* are usually called the *trunk.* The "collar bone" and the "*shoulder blade*" are attached to the trunk, and thus are a means of connection between the upper extremity and the trunk. The "spinal column," or back bone, is not a solid bone, but consists of 33 vertebrae, and tough elastic pads placed in between these irregular bones, called *vertebrae* because of their position, shape and movements. The head and trunk are kept firmly in their respective positions by the spinal column, which is 28 inches long, one-fourth of which is made up of those intervertebral *pads,* or *discs.* These pads are compressible, and consequently we are shorter, slightly, at night than in the early morning, because we rest at night and allow them to expand. The legs, thigh and foot are directly attached to the lower part of the trunk. So we can readily notice the importance of this spinal column, and we also, on closer examination, find that it is constructed so that there is a *hollow canal* running the whole length through this column for the protection of the spinal cord. This column is movable, but the central or dorsal region is more fixed, to protect the lungs, heart and connections. Flexibility, elasticity and the presence of numerous curves in its formation add to its mechanical importance and great strength in the human econ-

omy, and *prevents* shock to the *brain* and *spinal cord,* a most important factor.

The sewing machine, the croquet amusement to English—excess; high-heeled boots for children, long hours at school-room desks and tedious horseback rides for frail girls will cause *deformities* in the weak by permanently bending or flexing the spinal column from these excessive uses in one position. Not only can these bones, but other bones may become distorted by undue and persistent pressure. In Peru and Brazil and Central America we learn that it was the fashion long ago to lash a board against the back of the head to *flatten* it, so that it would conform to the fashionably shaped or high-typed head. Now the Chinese place their feet in moulds and tight bandages to shape their pedal extremities to fashion's ideas of beauty. Even the chest may be, and is, frequently distorted by tight lacing, thereby contracting the waist, which means pressing the ribs in toward the central line and forcing the liver and stomach backward and downward.

Bone Growth and Repair. Living bone is constantly undergoing changes under the influence of the cell arrangement embedded in it, and in the living body, is continuously being absorbed and reconstructed. We know that any pressure upon bone, as a tumor in growth-expansion, will cause a bone absorption and disappearance, if long continued. If a bone is fractured a surgeon's attention is required as early as possible, so that he may *set* the broken ends or bring them in contact in their normal relation to the soft parts and other bones. By so doing we allow "nature" to "heal" the broken member by building new tissue cells *between* the broken ends. If allowed to remain without correct surgical attention, swelling occurs and pushes the broken ends from their normal relation. This may permanently injure the limb, especially if it be one of the forearm bones. With a suitable splint or bandage (preferably a good splint) placed correctly upon the injured part, a bone *knits* or *unites* in about four weeks; in the young earlier, in the old later, sometimes never a perfect union. The experiment, shown by feeding an animal with madder, a red coloring matter, for a day or two, proves that the bones become slightly tinged; then,

if withheld a few days, the original color returns. If an accident occurs, as it usually does, while the person is dressed, do not remove the clothes, but tie one leg to the other carefully, or place a padded board the length of the limb; or if an arm, do likewise with pasteboard or whatever you have at hand, then pass a handkerchief or piece of muslin around it, and tie or pin to the neck of your patient's coat. This rests

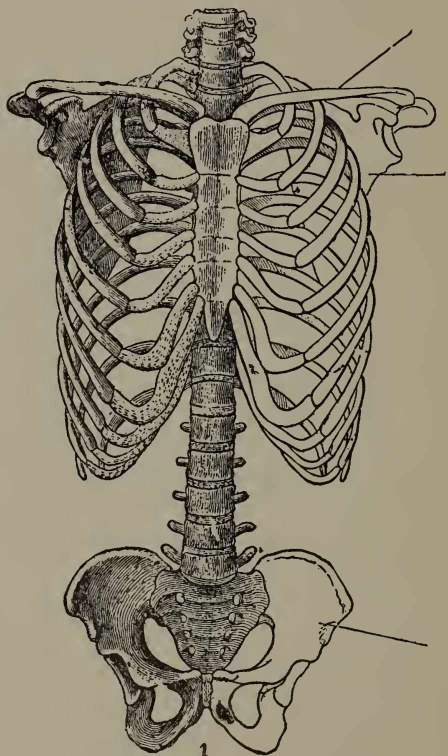

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FIG. 11.—Normal chest, pelvis, spine and shoulders.

the injured soft parts and will prevent injury to excess till you reach a physician, who will then correctly dress and place in splints proper for the bone so injured. Bones grow till we are about 25 years of age, and they begin to decay or weaken at about 45 or 50 years of age. The head bones are said to grow and expand till very late in life in a man who uses his mental faculties actively and is a thinker. This is

to make room for the enlargement of the exercised brain, which increases in weight and in convolutions according to our stimulus; just so a muscle will grow if healthily exercised or trained; and we find that bone, too, grows in strength and elasticity by judicious exercise. Of all the varied structures of the Human Body, bones are possibly the most important, for they *protect*, *support* and act as highly important levers, by which mechanism we perform most all of our skilled movements, gestures and accomplishments. Bones, indeed, are not dead, but living tissue.

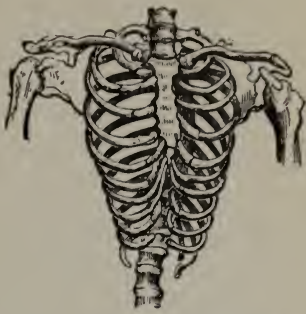


FIG. 12.—Abnormal chest, spine, ribs, showing the effects of tight lacing.

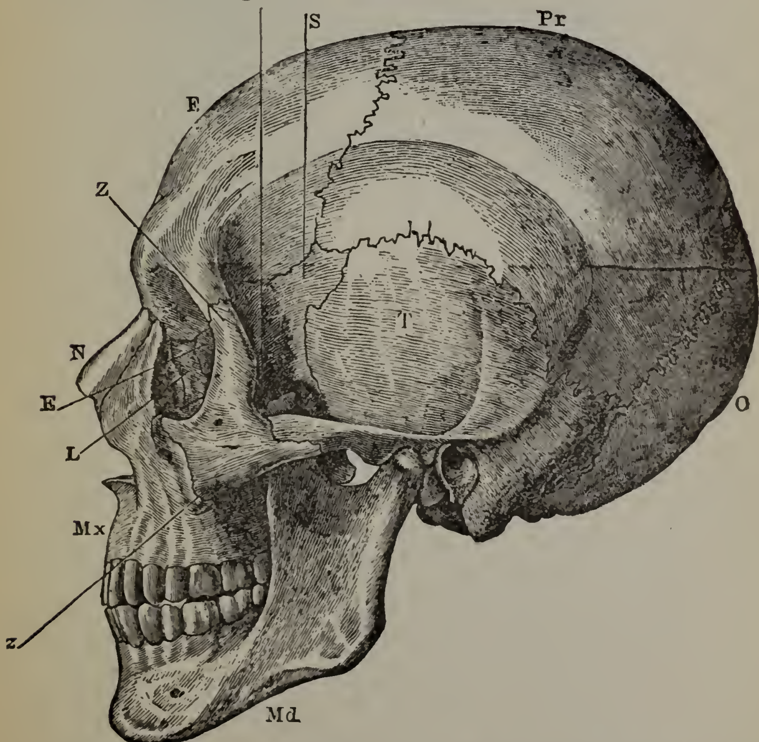


FIG. 13.—A side view of the skull. *O*, occipital bone; *T*, temporal; *Pr*, parietal; *F*, frontal; *S*, sphenoid; *Z*, malar; *Mx*, maxilla; *N*, nasal; *E*, ethmoid; *L*, lachrymal; *Md*, inferior maxilla.

CHAPTER V.

ARTICULATIONS OR JOINTS.

We have learned that the 200 and more bones found in the Human Body are not united in a *solid* and *immovable* manner, but are, most of them, *movable.* Some few, like the bones of the *head,* are *immovable.* However, our bones are for leverage as well as protection and support, and we expect, and do have, mobility, with a few exceptions. Then, we may

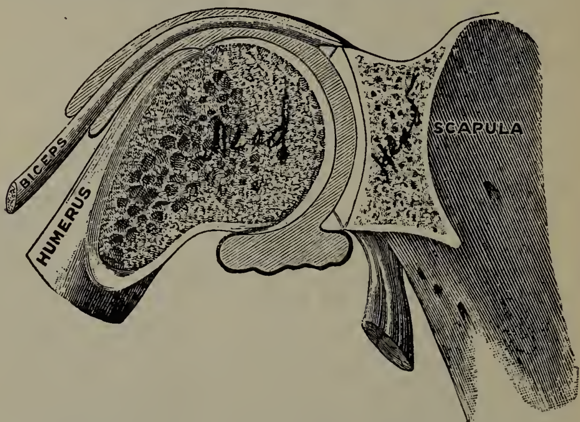


FIG. 13½.—Shoulder-joint in coronal section, front view. The synovial sac is distended. (Testut.)

classify our joints into the *immovable,* or *head bones; slighty movable,* or *pelvis bone* and *vertebrae,* and *freely movable,* or *shoulder, hip, elbow* and kindred joints or articulations.

We may take the shoulder joint as our most movable articulation. With that and all movable joints we must have our bony surfaces covered with a smooth, shiny, slippery, tissue called *articular cartilage.* These tissue prevent bone *friction,* which would occur necessarily if the rough, hard surfaces of *bone* were placed in apposition. In diseased joints frequently these *articular cartilages* are eaten away, thus *exposing* the rough bony parts, which causes excruciat-

ing pain. Thus, we learn the importance of such *articular cartilages.* Now that we have the bony *ends* covered with smooth cartilage, we must have some strong-inelastic tissue to hold the articular ends in contact, and this structure is called *ligament.* It has no power other than strength and inelasticity. Some few are elastic, but they are found in the *neck* or *cervical region* specially, and are economizers, for they save muscle energy.

To lubricate or oil, or to make smooth and easy motion to a joint, we have a shiny, moist membrane, called *synovial,* which secretes a fluid sufficient to make the movements of the joints easy and without friction to the bone surfaces. *Blood vessels* and *nerves* supply not only *bones* and *ligaments,* but muscles, and every tissue in the body, with a few exceptions, which will be considered later.

CHAPTER VI.

THE MUSCLES.

Muscles, through the intervention and absolute control of the nervous system, cause locomotion or movement by using the bones as levers. All animals and plants have motion. It is, indeed, difficult to tell where plant life ends and animal life begins. There are special plants which, like *Venus' fly trap,* have fine hairs on the leaves, and when these are touched by an insect the leaves close quickly, and so imprison the animal, which is subsequently *digested* and *absorbed* by the leaves. The *Sensitive plant* will lean toward a person if that person sits near it. Numerous instances are recalled where plants will close in the evening and expand in the early morning. In Bagdad we know of a flower which elects midnight to open and bloom. But ordinarily the plant life and muscle life depends upon, indirectly, the *Sun's rays* for healthy motion. The most distinctive property of muscle in animals is possibly the power of spontaneous movement. As far as *mobility* is concerned in the plant and in the animal, biologists cannot draw a precise line of demarcation between them. It is noticeable in animals that they are most always slightly *moving* in some parts of their bodies, for even in sleep our hearts and lungs move. Then, we have two kinds of muscle—one is *involuntary, unstriped,* or *acts without* our willing it; it has a spontaneous power. The other is *voluntary, striped,* or acts with our willing it. It is, then, controlled by our *will-power.* Physiologically and broadly speaking, *plants* develop especially the *nutritive tissues,* while we find that the *animal tissue* has extra characteristics, viz: *motor* and *irritable* properties, besides *nutritive.* Of course, these are only well marked and appreciated when we compare a complex animal, like a dog or a man, with a very complex plant, like a pine or an oak.

Spontaneity is man's highest characteristic; he *moves* of his *own accord;* plants usually have to be moved, except

in their *nutritive efforts* We recognize the *muscle tissue* in the *lean* of butchers' meat. *Amoeboid cells* can only *move themselves;* and *ciliated cells,* the *layer* of *liquid* with which

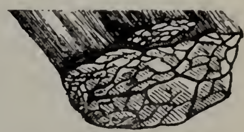
FIG. 14.—The Muscles.

they are in contact; but *muscle tissue,* being fixed to the bones, can, by contraction or relaxation, change the form and relative position of most all the parts of the body. *Skele-*

ton, ligaments, muscle and *nervous system* are correlated systems; one invariably depends upon the other's development for its greatest usefulness. The greatest *intellect* would suffer for utility were the muscles less fitted to carry out man's dictates, or his joints less numerous or mobile, or his bones frail or diseased. The heart muscle is an exception in not being attached to bone, and its microscopic study shows it to belong rather to the skeleton muscles, or voluntary group rather than to the involuntary. Jugglers of the East are, indeed, supposed to have some kind of voluntary control of the heart, for they seem to be able to *stop* or *slow* the heart action at will. This is a most profound phenomenon, if true. We find exceptions to most rules, however, and in our common "fidgets" of nervousness we certainly do not *will* the extraordinary abnormal movements, yet these irregular jerks are brought about by our supposedly *controlable* muscles, or voluntary ones. A simple form of skeleton muscle has a contractile belly or middle part, and two tapering ends, attached to bone by one or more dense white inelastic cords. These cords are fibrous white connective tissue, and are called *tendons*. Muscles are long, ribbon-like, short and square, or triangular and irregular, sometimes two-bellied, etc. The belly has the power of changing its shape, contracting or relaxing. The tendons being fastened to different bones, move these bones at the will of the muscle through the nerve influence. The tendons may be very long and the muscle belly at a great distance, as the finger tendons, with their corresponding muscles in the forearm, and many others. This is to preserve symmetry and beauty. The Tendon of Achilles (hero of Grecian poet) is the largest one in the body; he is supposed to have been vulnerable only in this part.

It is said that there are thirty-four distinct motions of the human hand. The hand is a special organ of man. Examine an artist's hand while executing a difficult piece of music, and note the many changes wrought in quick succession; now uplifted, then suddenly, with force, placed upon the right key or string, and almost before we realize it, the forceful, strong touch has been replaced by a dreamy, faint, melody, realized only by the most precise, yet delicate touch. A skilled pianist can produce 640 notes in

a minute, and 960 notes if extremely rapid. Electricity, or a sharp blow on a muscle may cause it to contract without our willing it. The *origin* of a muscle is at its most *fixed point;* the insertion is at its most *movable* point. In studying its minute structure we find a muscle made of an outside membrane, and within a number of bundles or faciculi running its whole length. One of these muscle fibres is about 1-3 to 1½ inches (8 to 35 millimeters) long, and scarcely 1-750 to 1-400 inch in diameter. Thus a muscle 1 foot long will have a number of short fibres to make one long one. Blood, nerves and lymphatic structures permeate these bundles and ramify in all directions. *Chemists* say that muscle fibre cannot be definitely analyzed, chemically, while living tissue; however, we know that a living muscle is faintly *alkaline,* but just before death becomes, through sarco-lactic acid formation, *acid in* reaction. It contains about 75 per cent. of water, and the phosphates and chlorides make up the other 25 per cent., with a little grape sugar and glycogen. Muscle *clot* is formed by squeezing out a quantity of muscle *fluid* on *serum. Boiled beef* or *muscle,* yields *salts, gelatine* and *flavoring* matters, which give us our popular beef extracts, so much used in exhaustive fevers. This is not a food, but more properly a stimulant. Our muscles are most always in a state of slight contraction or *tone.* The *flexor* muscles and the *extensor* muscles are slightly acting all the time, as shown by our hand; we neither have it clinched into a fist, *flexion,* nor do we have it flattened, or *extended;* but a happy medium is preserved, viz., half *flexion* and half *extension.* Ready to shake a man's hand, or knock him down on slight notice. Our *reflex* nerves, then, protect and guard our bodies by acting upon the voluntary or skeleton muscles.



FIGS. 15 and 16.—Muscle and torn muscle fibre, respectively.

Muscle Hygiene. Healthy, open air and sunlight exercise is the best tonic for muscle tissue. Unused muscles, atrophy or weaken and gradually lose their power of *contractility, etc.* The best of food makes, with the above

necessary rules, the strongest and most tireless muscles. Hence, the vast importance of our gymnasiums of today; and if we, like the Romans, had better *bath* facilities, our health would be better, and we could then wear even larger and heavier shields than the old heroes. For fear of a paralyzed muscle becoming permanently useless we *move it* by electric stimulus regularly. We see the lack of exercise in a broken arm, held by the surgeon's splints, resulting in very slight motion, after removing the splints, till *exercise* is ordered. Then the muscle finds slowly its *power* of contractility and leverage.

Walking, running and rowing exercise admirably tne lower extremities. Better still for an all-round development try those above, and also cricket, baseball, boxing and lawn tennis, to develop the upper extremity. The upper extremities need less development than the lower.

Children have little control of their muscles. Watch an infant try to get its hand into its mouth; it is just as apt to put it in its nose or eye. A healthy infant moves, when awake, incessantly; feet and hands are going in all directions; it grasps at objects, coils up and stretches full length, with head and heels pressing hard upon the bed; thus, it learns to exercise its power of motion. There is no better rule than placing a three months' old child, daily, upon the bed unhampered, without numerous clothes, and allowing it to wriggle and twist to its full pleasure. It will early learn to use its limbs intelligently, and with strength and great pleasure to itself. To use tight and heavy clothes all day on a child is vile cruelty. Never tempt a child to crawl or walk when it seems disinclined. It may injure it eventually. The bones and muscles are weak, and they feel it, yet do not know the importance of *rest*.

Young children from five to youth can be permitted to try almost any kind of exercise. Too great a tax on the bones should not be allowed, however, as the epiphyses of many long bones are not firmly united, and cause damage if broken loose from the shaft of the bone. Women's debility and ill-health is usually due to lack of exercise in the open air. If "dolls" were annihilated the stamina of the females would be largely improved and strengthened. Loose

shoes and loose waists are good for girls, and open air and sunlight. Rowing and horseback riding are excellent exercises for girls and women.

Age Limits in Exercise. After forty sudden efforts should be avoided. He should not try to run in a quarter-mile race with the young, for the blood vessels and cartilages are beginning to get hard and rigid by 40 or 45 years of age. Better for the 45-year-older to walk two miles briskly; driving to and from the office should be seldom. Walk, and *health* will keep you company; ride, and *disease* will keep you company. Old age forms its own habits of exercise, which are most frequently walking and riding. Invalids should follow the advice of their physicians. Exercise good for one is injurious for the other. Pulleys found in the gymnasium and home are good for all ages if used moderately night and morning. Becoming short of breath, easily proves that you are not in *good* training. Your muscles, especially your heart, *rebels*

Muscular Power in Animals. We learn from Emerson "that life is a series of surprises," and in no sphere are we so much surprised as in the relative comparison of strength of animals. Well grounded experiments show us that man, "the lord of all creation," can drag almost his own weight on a level. The heavy horse, man's bitted slave, can pull a weight equal to 2-3 of its weight, so that the horse, being much heavier than man, cannot be considered so powerful.

No living thing is so strong as the insect family. They can, seemingly, carry with ease objects much larger and vastly heavier than their own bodies. Some drag bodies 10 or 20 times their own weight. A peculiar variety of beetle has been known to carry to considerable distance, bodies 40 times their own weight. In strength, relatively, therefore, we are much weaker than the ant or the beetle, yet stronger than the horse. Action is nature's law of developing force. We should *educate* our *bodies* as well as our *brains*. Movement of the chest muscles means healthy and quickened movement of the blood and the exhalation of air from and through our bodies, which purifies and cleanses the system. To feel good and strong is to feel healthy. Rest and sleep,

too, are necessary functions in health getting. Exercise, till proficiency is attained, gives very little pleasure. Exertion is at first quite disagreeable. Excess exertion is worse than neglected exercise. The arm of the railroad engineer or of the blacksmith develops wonderfully by regular exercise with the hammer; but too much strain of the artisan will be at the expense of the heart, liver or kidneys. Ancient Greek and Roman athletes were short-lived. Getting "out of breath" should mean to all alike, *rest*. It is told "that the dervish in the Eastern allegory, knowing that the world attached little value to things which were plain and easily understood, knew that it would be in vain to recommend to the Sultan, for the cure of his disease, simply to take exercise." He knew that mankind in general, required to be cheated, gulled, cajoled even into doing that which is to their benefit. He did not, therefore, tell the Sultan, who consulted him, to take exercise, but he said to him: Here is a ball, which I stuffed with rare herbs, costly and specially medicinal. That ball is to be beat with this bat every day till your highness perspires freely. His highness did so, and in a few days was well. *Exercise* cured him. "Health means the uniform and regular performance of all its functions," says Dr. Nathan Allen.

Gymnastics and music were taught by the ancient Greeks as common education, and Plato, in urging these rudiments, maintained that the soul was superior to the body, and religion was the crown of all true culture.

Rest. We are supposed to work eight hours; recreate eight hours, and rest eight hours. Rest is essential after our daily exercises in the office or in the field. Sleep is the most relaxed and helpful way of resting, but often we rest well by simply changing our employment. The above eight-hour division is supposedly from Alfred the Great's common-sense application of labor and rest. If we do mental work daily, then physical work should be our kind of recreation, and if manual or physical work is the way we carve out our livelihood, mental exercise should be our recreation.

In sleep, circulation and respiration diminish, and the temperature falls about 2 degrees. Consequently, we need more covering on the body than during the wakeful hours.

The mind and body are always wholly at rest while we sleep. If we dream, that is so transient and fleety that we need take little notice of it. Physiologists all know, however, that a highly important and most interesting physical process is performed during sleep-hours. *Tissue nourishment* goes on, and a most important change in *tissue-building,* too, takes place while we rest and sleep. Thus, we repair our over-worked brains or tired muscles and awaken fully invigorated and prepared to begin another work day. Some men require little and others require a great deal of sleep. From 7 to 9 hours should be sufficient. It is said that Descartes required ten to twelve hours sleep, and Pascal still more. Great, plodding, researchful men like those possibly break down a large amount of tissue, and *time,* is required to build it up anew. Napoleon Bonaparte could pass days within his saddle and require only a few hours rest. Frederick the Great required about five hours daily. Dangers are near when sleep is away. Insanity follows closely, sleeplessness. At times, stupor overtakes the man who has lost for a long period his rest, and may never leave him. Sailors have fallen asleep while at the guns in action. At Moscow, the French soldiers would fall asleep while retreating, and the cry of, "The Cossacks are coming!" would awaken them only a few minutes. Railroad men, often fall asleep from sheer exhaustion and need of sleep—rest.

Frequently alcohol causes a deep sleep. Alcohol seriously affects the tissues and organs generally in our bodies if taken at regular intervals. It is not a food, but acts as such, in exhausted fever conditions. Injected under the skin, it will, in 20-drop doses, stimulate the weakened tissues and organs temporarily, but great care must be taken, for it leaves the patient usually in a weaker condition than he was in before using it. Long ago tests have conclusively proved that *alcohol* is not so good for soldiers, sailors or workmen of any type, as a lasting and healthy stimulant—coffee. It seems to add nothing to the body force, but only temporary energy is gotten from its use. Men in training for any athletic sport, requiring hard, strong, enduring muscle fibre, are prohibited the use of alcohol. Arctic explorers soon learned that alcohol was a

snare for them, and they readily forsook it and preferred *fats* and *oils,* the real heat producers and energy formers.

Alcohol produces abnormal movements which are harmful. The tongue is the first muscle to lose its natural function and becomes "thick," we say, in speech; his words are arranged peculiarly and unintelligibly. If we watch a man heavily under its influence we notice his legs illy supporting his body, and it is a familiar sight in large cities to see forlorn pedestrians under its toxic influence, clinging to the lamp-post for support. If not arrested he soon tries to brace up and start on his way again; when we notice shortly after, that he is in the gutter, too weak and unsafe to try and stand up longer. Food and drink we will discuss later.

CHAPTER VII.

PROTOPLASM OR AMOEBA.

In beginning our study of Physiology proper, we take as a common type of low-order living, the Amoeba, or, technically, Protoplasm. A cell, as referred to previously, is too complex and intricate in its structure and properties, because it contains a subtle something, extra of its protoplasmic properties. Therefore, for purposes of clearness and simplicity we compare the homogeneous mass, amoeba, with

FIG. 17.—A white blood corpuscle dividing, as observed at seccessive intervals of a few seconds with the microscope.

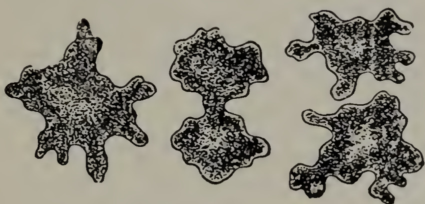


FIG. 18.—Amœboid movements. (Hackel.)

dead bodies; admitting that amoebae are necessarily *living tissue* cells, and when dead, are no more amoeba. *Life* is their important all. Without life, they are not amoeba. They are unicellular animals of very simple composition, as shown by above plate. Their place of abode is only in water or mud, containing in solution certain gases and in suspension, some solid food products; if the water is removed death speedily results, so also if the gases are removed or if the solid food is liberated. We also find in yeast a queer unicellular plant, which thrives and multiplies only in liquids of certain composition. Both the amoeba and the yeast cell require certain different medium surrounding itself.

What, then, does distinguish *living* from *dead* objects? Living things are constantly undergoing a perpetual change of the particles of which they are composed. The *amoeba* being a low-order of living tissue, semi-fluid, simple, jelly-like mass, homogenous throughout, and recognized only by the use of high magnifying microscopes. A *stone* cannot change its particles, position or shape; but the *amoeba* can. Why? Because it is *living tissue.* What are the changes known by experiments to take place in the *amoeba?*

Disintegrating, or continually gaining new matter and changing it, then throwing off or losing the old matter, is a high and important function of this simple wall-less cell, which we use for comparison, and also use for the purpose of making lucid the properties of our own body structure. These simple motor tissues, *amoebae,* are, in the adult Human Body, regarded as the slightly modified descendants of the undifferentiated cells, which at one time made up the whole Body. They are not attached to other parts; therefore their changes of form only affect themselves and produce no motion in the rest of the Body. They are motor tissue, but not, correctly speaking, representative motor tissue for the whole structure of the human adult. As we grow and develop from our primitive simplicity we find that the cells undergo marvelous changes, some differentiating themselves into nutritive, secretory or respiratory cells. In brief, becoming separated and individual specimens of cell tissue, with varied functions, as *Nature* dictates.

The Amoeba, then, is continually taking in, changing and eventually throwing out as waste all unnecessary atoms of tissue. This applies to all living matter. In man we have a peculiar apparatus for some of these changes, as the lungs, the liver, the kidneys and many others. The most important characteristics of the amoeba are the following:

Contractility. From external stimulus, as a touch, or heat, or cold, we notice motion. It changes its shape. Protoplasm, then, has the property of mobility, which is well and wonderfully developed in the adult muscular tissue.

Spontaneity or Automaticity is the property which it possesses of changing its shape and position, of its *own ac-*

cord, without any interference of outside agents. This we find in the lungs and liver.

Irritability is practically the same as contractility in the amoeba; it's action from touch or pricking.

Conductility is the property by virtue of which it carries impressions to all parts of the body and equalizes or systematizes their action harmoniously.

Interstitial change is similar to the perpetual and continual disintegration of matter, motion by and through its power to digest *foreign* matter, *build up* its structure and *eliminate* or *excrete* broken down tissues found unnecessary for its own existence.

Metabolism means chemical reactions and changes going on in the Body, almost incessantly.

Anabolism means *constructive* or building up chemical changes in our structure, and *Catabolism* means breaking down of our tissues, or destructive chemical changes going on in the Body.

Sensation is a most interesting and scientific power of amoeboid tissue through which it moulds itself into definite shape and form; the ovum or cell of a man and the ovum of an elephant are almost identical in appearance, yet one queerly enough develops into a man and the other into an elephant. This is a result of their individual inherent sensitive power.

Reproduction is the property by which protophlasm begets its own kindred, through its nucleus.

Assimilation is the important quality the amoeba has of breaking up whatever tissue it happens to digest; absorbing and supplying each separate part of its structure with appropriate or needed nutritive properties. In our bodies a muscle needs different nourishment from the finger nail or hair; assimilation is the power, then, of distribution of nutritive products where needed, and in correct quantities, for a working organ needs more than one at rest.

Retention of impressions is a high power of amoeba, which it stores away and subsequently repeats; it also has the previous power of *receiving* impressions, then transmitting these impressions, possibly changed; or it may, under-

certain circumstances originate *new* ideas and transmit them of its own accord. We have no higher power.

Heredity is, too, supposed to be one of its properties, which means hereditary transmission of simple tissue.

Heat formation and generation is also a peculiar power of the amoeba, illustrated by our animal temperature of about 98 2-5°F. It regulates its heat.

Temperature, then, is thus regulated by amoeboid power.

Definite Composition is a most eminently important characteristic of protophlasm; and this fact is discovered by noting that the amoeba floats in water, it will absorb only a limited amount in its substance; but when it *dies,* it swells up very much larger in size from *more* water passing into its structure.

Living Matter, we find, is constantly undergoing changes. An amoeba of today, though occupying the same position relatively, is not the same, for it has taken in *new* and thrown out *old* matter. The phenomena of life are all produced by molecular death, as our every motion, speech and thought, is executed by such death. Thus, "unless we die, we cannot live, paradoxical as it may seem;" so everything we eat or drink is changed to something else, which in turn is killed and thrown off. Man, therefore, is a great aggregation of "amoeba," as it were. Great masses of them are banded together for one purpose specially, as in the liver or kidneys. What do we call this matter? Protophlasm or amoeba.

Chemically, do we know its composition? No. If we examine it we kill it necessarily, and this destroys its real properties. It is, then, no longer the same structure. We know, however, from the careful analysis of its ash, obtained by burning protophlasm in a platinum dish, that it contains but few chemical elements, viz: Carbon, hydrogen, oxygen, nitrogen ,sulphur, phosphorus, frequently, and certain *salts,* which salts have a highly important something to do with life and protoplasmic composition as well as *health* and *disease* in ourselves. Placed in a solution of these salts, a protoplasm will contract and mechanically show its living characteristics. If an acid or an alcohol is brought

in contact with it, movement ceases suddenly. Water forms about 80 to 85% of amoeboid structure, and is in combination; if extracted, the amoeba dies.

Vegetable Protoplasm is a less highly organized form of protoplasm and takes its nutriment from the *air, water, light* and *earth,* and arranges these particles in the form of food and kinetic energy.

Animal Protoplasm is the highest type of protoplasm. It derives its nourishment from the *vegetable* and other simple animals, and generated from these will be heat, motion, disintegration, thought—the big, best physiologic factor—and numerous other properties.

Cells are something more than protoplasmic structure; they are a higher type. The amoeba is the simple form of living tissue, while a *cell* is a further development, being more complex, with *structure* and *individual specially-endowed* component parts. *Animal* cells *may* or *may not* have cell walls; *plant* cells *have* a distinct cell wall. All cells, animal like, are composed of a body, *nucleus,* and frequently a *nucleolus.*

The Body of a cell is, structurally, made up of two parts, a network of fibres, called spongioplasm; and a hyaline fluid, transparent in character, termed hyaloplasm.

The Nucleus of the cell has a well-marked wall, and is similarly composed of two parts, *chromatine,* a fibrous tissue, and *achromatine,* a liquid.

The Nucleolus is a shiny, glistening spot of protoplasmic tissue.

The functions of these cells are ordinarily the same as the simple amoeba, but of a higher character.

Reproduction is supposedly caused by the action of the nucleus; non-nucleated cells have no such power.

Karyokinesis means the manner in which a nucleus or body of a cell divides by a complex loop or skein arrangement or in a direct manner, respectively.

ELECTRO-PHYSIOLOGY.

Formerly, Physiologists would not consider this scientific reasoning at all.

The eggs of the fundulus, according to Prof. Loeb's recent experiments, after having been fertilized, will develop in sea water. In a chloride of sodium solution they will not develop except by adding a trace of calcium; then they will develop as in the sea water. This, he claims, is due to the *electrically* charged atoms of the calcium. He tells us that you can only bring about the generation of a new creature by unfertilized eggs, by *positive* ions (or substances resulting from decomposition by electrolysis.) And the power of salt to produce contraction increases with the valency of the ions. His conclusions are two-fold. First, rhythmical contraction occurred, only in the presence of *electrically* charged substances; second, the efficiency of the charges depended upon the number of different ions.

Prof. Mathews arrived at a third conclusion—that the negatively charged ions produce stimulation, while the positively charged ions retard contraction. Indeed, these experimental facts seem to have revolutionized the basic principles of Physiology. Life phenomena is a microcosm in itself. In his novel experiments, Prof. Loeb suggests a close identity between stimulative action in chemical ions and light waves. Light, then, may eventually be used for therapeutic purposes more specifically and specially than previously. The X-rays, therefore, may yet be a very potent factor in treatment of diseased conditions. According to same writer, there are certain germs which prefer *suicide* to that of a watery surrounding; they have water antipathy, so to speak. Surgically, we find that ordinary cold water will *irritate* a wound, but by the addition of a little salt, will soothe and comfort the part.

CHAPTER VIII.

CHEMICAL COMPOSITION OF THE BODY.

What are the chemical constituents of the body? For present purposes they may be classified as *Organic* and *Inorganic;* and the former, be subdivided into the *nitrogenized* and the *non-nitrogenized;* one containing nitrogen, the other not containing nitrogen.

Inorganic constituents are mainly of the simple variety, They are from the mineral kingdom, and are inanimate forms. These really are not essentially foods, but they enter so largely into the composition of food that we so consider them. While entering the body in combination with organic substances only, we distinguish from them water and salts, as they may enter the body singly or uncombined.

The Principal Constituents of the *inorganic* variety are oxygen, hydrogen, carbon, nitrogen, sulphur and phosphorus, with the addition of calcium, sodium, magnesium, fluorine, iodine and traces of other substances. Most of these are found in combination, not free, but in what we call salts. Oxygen is the most abundant of all these elements, numbering about 16 of the 70 known elements.

Oxygen is in nature found everywhere, ready and easily combining with hydrogen to form *water.*

Oxygen also combines with the effete matter, or waste, to help facilitate its elimination from the system. Oxygen is obtained from the air we breathe in large quantities, and it leaves the system almost entirely in the form of carbondioxide and sweat. *Hydrogen* is free in the intestinal canal, but is found combined in the body proper. We take hydrogen into our bodies in food and drink, and it is there combined, and if living material is decomposed, hydrogen is then liberated, which, being in a nascent state and coming in contact with the omnipresent oxygen, it forms water.

Water makes up about 60 or 65 % of our structure, and is possibly the most valuable ingredient. Some of the water

is generated or secreted in the body, but most of it is taken in as drink, or as part of our food diet. Every tissue in the body is bathed by water, and in some mysterious combination, is held in the protoplasmic tissue of the body. Take this water away from protoplasm and we have immediate death. It seems to be most essential, even as much so as the water of crystallization is, to a crystal of copper sulphate.

Water evaporation is prevented by the important radiating power of the oily skin tissue, which prevents dryness, and thus inadvertently checks the progress of death. Dry a man weighing 165 lbs. and he would lose about 110 lbs from water evaporation alone, showing its relative quantity and proportion in our bodies.

Enamel of the teeth contains least water (about 2%), and saliva most (about 99.5%) ; between these two extremes are all intermediate steps—bones, containing 22% ; muscles, 75%, and blood 79%. Man can remain a longer time without food than without water, for it is essential to every fluid of the body and to every intestinal change. It not only helps to build up the tissues, but it helps to cleanse the body, and purge it of discrementious material.

Food should contain about two parts of water to one part of solid nutriment. Within 10 hours, if water is withheld from man, he suffers pain and great weakness ; but he can do without solid food longer and with less distress and fatigue. Fruits, drinks, vegetables and meats are principally formed by water. Fruits are, indeed, excellent substitutes for drinking water, and are highly nutritious, too. Water is help in the body frequently in a most mysterious manner, as in the *fever* cases ; they take in enormous quantities of water, yet they do not eliminate but very little, either by the skin, lungs or kidneys, till the febrile process subsides ; then it rushes out through the skin, and especially through the kidneys, as urine. A starving animal will hold more water to his body, proportionately, than a well-fed one ; the system, then, clings tenaciously to water until the end. *Hydrolytic* power is that by virtue of which tissues seize water and store it up into their own substance. Some one has said that "water makes our bodies a running stream." The only natural drink of man is water. Soft water is more whole-

some than hard. Ice water is, in hot weather when the body is overheated, injurious and may cause death. Water will sustain life even, as we have seen in many instances, almost as long as two months. A man in 1836 in New York lived on water alone for fifty-three days. He was able to walk outdoors for the first 40 days, and even on the day of his death sat up in bed.

Nitrogen is found in the body only when combined with some other gas. We know little about its function. It will, however, combine with organized or unorganized bodies all alike, whether human or otherwise.

Sulphur is also found uncombined in the body.

Common Salt—sodium chloride—(Na Cl) found in all the tissues, and liquids especially, and in many cases helps to keep other substances in solution in water. These salts are most important factors, and are equally as important as the water, hydrogen or oxygen of the body. Extract these principals from food and the animal so fed will soon die. This is caused from the fact that the sulphuric acid, which is made by the decomposition of the protoplasm, finds no base to unite with, and therefore destroys the body. Salt is in the body in the proportion of 4-10 of one per cent. We use it at the table as a condiment of great value; it helps to alkalinize the tissues, which is preservative, and also assists in waste elimination. Salt withheld from the tissues will diminish the alkalinity and consequently the firmness of their structure.

Iodine is found in the milk of the female, and in the saliva, thyroid gland and in the urine of a patient taking the compounds or Iodine itself. They are combined, and this is shown in the saliva; for if discontinued we still find it in saliva. They, like the salts, assist in elimination of waste.

Potassium Chloride (K Cl) is found in the muscles, nerves, blood and most liquids, slightly. Principally found in solids. It is combined with phosphorous and other elements to form salts. In certain conditions potassium salts are very poisonous, if in abnormal proportion, for example; but if in normal proportion, health reigns. These salts being in the solid tissues, electively, when we have breaking down of solid tissues, necessarily we have an excess of these

salts. During exhaustive muscular exercise we find the *urine laden with* potassium salts, and it is a *grave sign* to find, in pneumonia, these salts increasing, for it proves that solid tissue is breaking down. They are especially harmful and poisonous to the nervous centres. We cannot by taking this salt in large quantities increase its amount, but it must enter into combination in exact proportion.

Phosphorous is found usually combined with K cl, N Cl or Ca Cl. In bones, we find in large quantities, the phosphates of calcium; in muscles, phosphates of potassium; and we find phosphorus extremely necessary and essential to the proper development and action of the nervous system. *Calcium* and Phosphorus combined are found in most of our tissues, bones, teeth, muscle, etc.; even protoplasm needs these salts. Bone softens and begins to decay, if these calcium salts are removed.

Iron may be found in combination with hæmoglobin of the blood and many other substances, and is equally as important to our life and proper functioning of the body as in vegetable matter or proteids. It helps stimulate hæmoglobin in its oxygen-carrying power, and is taken up by the system in some unknown way.

Hydrochloric Acid (Hcl), uncombined, is found in the stomach. Ammonium chloride is also found in the tissues of the body, with other less important constituents called inorganics.

ORGANIC CONSTITUENTS.

These constituents are those which are found nowhere else than in the living matter. Most of the water, as we said, was generated or formed out of the body, but a great deal is formed inside of the body. Serum contains the inorganic Na Cl, and the corpuscles the K Cl.

Nitrogenized and Non-nitrogenized substances are the two divisional classes of the *organic* matter.

Non-Nitrogenized, which are again divided into the *Hydrocarbonates* or *fats* and *oils*, and into the *Carbohydrates*, or *sugars* and *starches*. And these contain C, H, and O, but no N.

Fats are all similar in appearances because of the fact that they do pass through the membranes. They all consist of a *fatty acid* and a *base,* are liquids at the temperature of the body, and they are insoluble in water. The *base* is glycerine. Three fats occur in the body in large quantities, viz., *palmatin, stearin* and *olein.* The former two, when pure, are solid at the body temperature, but in them are mixed olein in such proportion as to keep them fluid. In an average sized man, 160 lbs., we find about 6 pounds of fat, sometimes more. It is all of beauty, because it gives contour to the body. Shock is broken by its padding the bones, and by its thick and even lining of the skin and fascia, and between these and the intestines we are kept warm as if by a double blanket. No overcoat is so warm as a good layer of fat or adipose tissue under our skin. It is also a great storehouse for food. A man cannot live on his fat, but we find in diseased conditions it is the first of the tissues used up. When we have degeneration of the muscle or organs generally, we find it is the advance growth of the fatty tissue; therefore, it is not only of Physiological, but of extreme pathological importance.

Why do the fats not flow out when a man is cut if they are fluid? Because they are contained into small "sacs." They are all *acids* in combination with *glycerine,* making *stearic, oleic* and *palmitic acids,* plus *glycerine, respectively.* They will not pass through membranes or unite with water, but they readily form soaps of chemical actions with alkalies, and then, when rid of the glycerine, they will dissolve in water. This chemical change gives rise to disagreeable odors, as we may notice in bad butter.

How do these fats get into the body? Partly from the foods we take. In some unknown way it enters into the cells, and may pass out when starved, and return again when well fed. These cells are, when the fat is out, filled with water or else shrunken. One of the secretions which is filled with fat is milk. Much of the fat must necessarily be made in the body, for a well-fed cow will give milk containing more fat than which existed in the food given her. Nitrogenized matter may lose its nitrogen and become fat. An example is in the formation of pus, which is antiseptic fat.

Fat may also increase in badly nourished people, while the essential element, albumen, diminishes. Feeling of nourishment is deceptive. The Irish peasant who consumes 10 lbs. of potatoes feels quite well filled and satisfied, but he is badly nourished, three-quarters of which was water. Fats and oils are highly necessary in cold climates; they need them for heat producers. The Esquimau consumes daily about 10 to 15 lbs. of blubber, or meat, largely composed of fat. The Laplander drinks train oil, and he regards tallow candles as a great luxury. Children who eat little fat, usually suffer with joint disease, sore eyes, enlarged glands, and even lung diseases may effect them. Parents should insist upon their children eating fatty or adipose tissue frequently. Fat, then, is a heat-producer; it produces slow combustion. In Dr. Hayes' exploration he found that often the Esquimau would eat ravenously of fats, but the temperature would be about 60° below zero; he consumed about 7 hours at his meals. To reduce our corpulency we should eat less; but who will follow that advice? Butchers are always fat, as a rule, because they eat so much nitrogenous or albuminous matter, which is readily converted into fat.

What becomes of this nitrogen, liberated? It forms *urea* and leaves the body through the kidneys and bladder.

Emulsification, means an alkali and a fatty acid combine to form a soap; then, this *soap* coming in contact with the remaining fats form an *emulsion,* by surrounding or enveloping them; by so doing they can pass through *wet membrane,* otherwise not.

Adipose tissue is fat plus an albuminous capsule. *A Bear* stores up an immense amount of fat in its tissues by eating large quantities of nuts, kernels of fruits and grain, and enters his cave fat and round, but he comes out in the spring lean and lank, because his fat has been consumed in keeping the smouldering fires of life burning. Fat is a slow fuel for the body mechanism.

Carbohydrates. These also contain C, H, and O, but they contain one atom of O. to every two of H. Chemists relate them to starch. The important ones found in the body are: *Glycogen,* found in large quantities in the liver, and in smaller quantities it exists in the *muscles.* It is an

animal starch; odorless, colorless, tasteless, and is soluble in water. Cupric Oxide solution dissolves it, but does not reduce it on boiling. Dil. Sulphuric acid reduces it to a form of sugar resembling dextrose. Amyolitic ferment will produce the same change. After death, Glycogen breaks up into dextrose.

Glucose, or grape sugar, is found in the liver, lymph and blood. It is largely derived from glycogen.

Dextrose is found in the alimentary canal, blood, Lymph, chyle.

Maltose is formed by the malt extract upon starch. *Lactose* is found in *milk normally* and in *urine abnormally. Inosit* occurs in the muscle, liver, spleen, kidneys, lungs and brain. Abnormally, it is found in the urine of Bright's and diabetic patients. *Dextrin* is formed by boiling starch paste with dilute acids.

Organic Non-Nitrogenized *acids* are Lactic, Formic and Acetic, principally, and Butyric slightly. *Lactic acid* is found in the stomach and develops in milk when it sours. *Sarcolactic acid* is formed in the muscles when they work or die.

Nitrogenized constituents are proteids, peptones, albuminoids and coloring matters principally.

Proteids are the most characteristic substances found in the body. They only exist in living things as plants and animals. Some are soluble and some are insoluble in water; all are insoluble in alcohol and ether. They are soluble in strong acids and alkalies, yet some chemical changes take place. These proteids have the highest function of all the constituents of the body. There is no such substance as *protein,* but we do have proteids. All proteids contain *Nitrogen.* All are non-crystallizable and non-dialysable colloids. Any crystallizable salt is dialysable. When they putrefy, or are destroyed, they give rise to a number of substances. During decomposition they form fatty acids by a rearrangement of atoms.

Albumen is one of the most important proteids, and we take it as a type. (1) When a solution containing albumen is heated it becomes cloudy by coagulation. The cloudiness is first noticed *just before* boiling, and an important thing to

notice is that *acid* will not destroy the coagulum. This should be tried first.

(2) Millons Test. The acid-Nitrate of Hg. coagulates it, and when boiled turns it redish, or pink colored. If the solution be acidified first it will not coagulate on application of heat.

(3) Render the fluid thoroughly acid with acetic acid, and then add a few drops of Ferro-cyanide of Potassium. The result is a precipitate.

Proteids are divided into seven classes: Native albumen, derived albumen or albuminates, globulins, fibrin, coagulated proteids, lardacein and gelatines.

Native Albumen is found in the tissues and fluids of the animal. They are soluble in water and coagulated by heating. *Ether* coagulates egg albumen, but not serum albumen.

Egg Albumen is an aqueous solution and a natural transparent faintly yellow fluid.

Acid Albumen is formed by adding strong acetic acid to excess till a jelly-like mass is formed.

Alkali Albumen is formed by adding strong caustic potash to excess till a jelly-like mass similar to the acid.

Derived Albumen is formed when a native albumen is treated by H Cl for some time. The importance of this change is that it will not coagulate by heat. These changes are all slow in transforming their identity.

Casein is a well-known albumen or proteid, existing in milk, and by some supposed to be in blood and muscle also. It principally forms cheese. Sour milk is casein precipitated.

Globulin is found in the red corpuscles of the blood, and dissolved in other liquids. It combines with a colored substance in the blood corpuscles to form haemoglobin, which is crystallizable.

Fibrinogen and *Paroglobulin,* found in the blood, and both helping to coagulate or clot blood at the injured vessel or apart from the body. The two, respectively, coagulate at different temperatures, 52c. and 65c.

Myosin comes from the muscles, in which it develops and solidifies after death, causing the "death stiffening."

Vitellen is found in the yolk of an egg, which is the chief constituent.

Albuminoids. These contain C, H, O and N, but no S. *Gelatin* comes from ligaments and bones by boiling; *chondrin* similarly from gristle. *Mucin,* which makes the glairy tenacious secretions of the nose and mouth is another albuminoid.

Urea, Uric Acid, Kreatin and Kreatinin are eliminated from the body through the kidneys, so also Nitrogen. *Elastine* from elastic ligaments like ligamentum nuchæ after the removal of gelatin. *Keratin* is the component part of hair, nails, feathers, bone and epidermic scales. *Chitin* component part of the exo-skeletons of many animals.

Peptones are very soluble in water; insoluble in alcohol. They are readily diffusible; not so with the others. Peptones are formed in the alimentary canal, by digestive activity of the juices upon the proteids swallowed. The proteids will not dialyze, but the peptones will.

Parapeptones are partially digested peptones.

CHAPTER IX.

BLOOD.

Circulation, Arteries, Capillaries and Veins.

Blood is used in the human being or animal, because we need some *internal medium,* now that we are made up of numerous amoeba and special cells placed at a distance from each other. A single amoeba breathes through the air surrounding it, and its *circulation* is of the crudest and simplest sort, not needing plasma, arteries, capillaries, veins and heart. This internal medium kept in motion, *receiving* at some surface of the body and losing at others, certain ingredients which go to *nourish,* and others to *carry away waste* products, all very necessary and important functions for the welfare of our bodies. This blood, then, acts a middleman, so to speak, giving up nutritious material to the body, and taking away waste products, which would injure the body if allowed to remain there. These products of nourishment and waste are found in the gaseous and liquid state in the blood and lymph channels.

Blood, then, is required for a high order of animal or vegetable life, and in order to carry this fluid to all parts of the body, we require a circulatory system, composed of heart, arteries, capillaries, veins and lymphatic structures. Blood is not found in the hair, nails, epidermis of skin, epithelial layer of the alimentary canal, enamel of the teeth, cartilages or the refracting media of the eye, but these parts on the interior of the body *are* moistened with a peculiar liquid which prevents their rapid evaporation. These are termed *non-vascular tissues, vasa,* meaning *vessel.* Wound any other part of the body and we have *bleeding.* In many lower animals their cells live slowly and require little food and produce almost no waste; therefore, they do not require a rapid circulatory system as we do. In a sea anemone, for example, no special system is needed, for he pushes the blood, through

his own movements and general activity. In man we find specialized cells, some for receiving food, crushing it, mixing and moistening it, digesting and absorbing it, and finally some to carry away the waste. All these functions must have rapidly circulating media, and for that reason we have *blood* and *rapid* circulation.

Pure blood is not found in the body. It contains, mixed in the highest, nutritive products for the organs and the effete material which they have thrown off. However closely or intimately mixed, they seem not in the slightest degree to interfere with each other.

Lymph. The blood comes only in contact with those cells which float in it, and those which line the interior of the blood vessels, because blood is found in *closed* tubes only; at certain parts of these tubes they are extremely thin, and through the walls of these *capillaries* liquid transudes from the blood, and then bathes the various tissues. This transuded fluid is *lymph,* and this it is which forms such an important aid to the blood in immediately nourishing the tissues as *plasma.* Prof. F. T. Miles holds to the theory that the lymph is *secreted* by the *vessel walls,* and not pressed through. The cells forming these thin walls (tunica intima) performing the function by their *vital powers.* Others say that the fluid is pressed through, and but slightly changed by the action of these cells as it passes. Every crevice of the body is soaked with *lymph.* It has two tubes to enter the blood vessels. The *systemic,* which is called *Thoracic duct,* brings the lymph from all parts of the body *except* the right upper extremity, right one-half of the head, brain, face, neck, heart, lungs and convex surface of the liver. Those parts have the right lymphatic duct and both of these ducts empty into either side of the neck at the junction of the sub-clavian and jugular veins, respectively These constitute the lymphatic *vessels* Lymph is a straw-colored alkaline fluid, saline taste, no odor and sp. gr. of from 1012 to 1022. The vessels have valves which prevent a backward flow, and they are remarkably thin. The lymphatics begin at the interspaces in the tissues and the cells. Every tiny nook or space is penetrated by these lymph vessels. Lymph, then, gives nourishment to all the cells and tissues of the body, and

in the course of these vessels we notice certain *nodular-like masses.* These are *lymph glands,* but they do not secrete. They seem only to act as guide posts or stations, keeping guard, and when irritants appear they at once swell and may inflame and suppurate. To repeat, the *blood* does not nourish the tissues, but the *lymph* does. *Plasma,* in a more diluted form, is lymph. The same proportion of salts, but the proportion of the nucleo-proteids and organic substances are *less* than in the blood and plasma. Lymph may also differ in the body at different times of the day as to its composition. After digestion we find lymph laden down with fats and organic compounds, which it has received from chyle. *Plasma* passed through a capillary wall by a *vital* act of the lining cells gives us then, *lymph.* It is modified in some way, while passing through these cells. The effete matter, or waste, of the system first passes through the lymph and later into the blood. The large lymph spaces or cavities are lined with endothelial cells, such as the pleural, pericardiac and peritoneal sacs or cavities.

Lacteals. These are found in the small intestines, and are called lacteal vessels because they contain a white liquid during digestion (emulsified fats) resembling milk, hence *lacteal.* These vessels are parts of a *villus,* which we will learn about later.

Dialysis is a theory advanced, concerning which, we believe, the lymph and blood each interchanging their contents, the blood gives through this lining membrane nutriment and the lymph baths the tissues with it; then the lymph, in return, gives its waste products (given up by the tissues) to the blood. *Omosis* is the same theory. However, most physiologists think these changes are brought about by the vital act of the cells themselves. This process of interchange between the lymph and blood takes place through the capillary walls, which are semi-fluid cells with a high function. The blood gives more than it receives from the lymph.

Gross Anatomy of Blood. Arterial blood is bright red; venous blood is dark red. The arterial is always red, while the venous varies greatly. *Venous* is a *dichroic red* under reflected light, and a *green* color under transmitted light.

Blood is opaque, thicker that water and sticky to the touch, salty taste, sp. gr. 1055 to 1060; drinking water decreases it; faint odor; when H_2SO_4 is added you get an odor like sweat; alkaline reaction caused by Phosphate of Soda and Carbonate of Soda; blood never becomes acid or even neutral under any circumstances. There is a difference of alkalinity in different people, or even in the same person at different times. Exercise lessens the alkalinity, and it varies, too, in disease. We don't find blood enough in the body to fill all the arteries and veins at the same time; we only have about 1-12 or 1-14 of the average weight of man, or something like one gallon of blood in the body. We can inject 80% of the amount of our blood into our vessels and we have little or no effect as to blood pressure, and some others claim that it takes 150% increase to burst a vessel. We can ordinarily find about one-quarter of the blood in the liver and portal vessels; one-quarter in the muscles; one-quarter in the tissues, and one-quarter in the lungs, heart and its large vessels. Some one has called blood "the vital fluid." The Mosaic law forbid the Israelites to eat food that contained *blood*. In the story

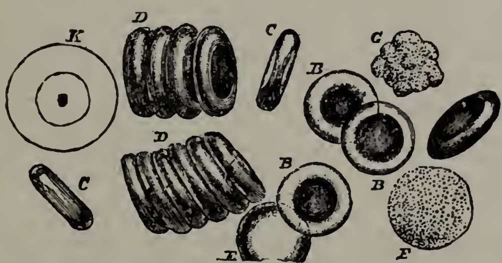


FIG. 19.—Red and white corpuscles of man. *C* and *E* are *white* and the others *red* corpuscles.

of the murdered Abel, it is written, "the voice of his *blood* crieth from the ground. *Sap* in plants, represents its blood. Insects have a watery, colorless fluid for blood. In fishes and reptiles we find *cold red blood,* but in the nobler types, in the animals and man, we find the rich, red, *warm blood*. Protoplasm gets its oxygen through the blood. It is this oxygen, by its presence, which gives blood its red color, and

by its deficient quality dark red blood. *Monocroic* blood is scarlet red, and *diocroic* blood is venous or black-red. *Laky* blood is blood with its hæmoglobin dissolved, making it transparent. Blood temperature differs in different parts of the body, being about 100° F. in the heart and about 110° F. in the liver and porta.

FIG. 20.—A white blood corpuscle sketched at successive intervals of a few seconds to illustrate the changes of form due to its amœboid movements.

Microscopic examination of blood shows it to be a fluid in which we notice little bodies floating. This fluid is *transparent*, and is known as the *blood plasma* or *liquor sanguinis*, and the *little bodies* are called *corpuscles*. We may get a drop of blood by pricking the lobe of the ear or tip of the finger, and receiving it on a glass slide, covering, protecting from evaporation, and examining with a microscope, find the above *fluid* and corpuscles.

The **Corpuscles** are named respectively *red* and *white*, and *blood plates* or placques.

Red Corpuscle. Blood gets its color from the red corpuscles. A single one of these corpuscles is not *red*, but *yellowish* in color. Only when closely placed or collectively are they *red*. These *red corpuscles* are *bi-concave discs*, as seen above, with thickened edges, round, flat and depressed in the center, resembling the oyster crackers so generally used. On examination we find the current still existing in the red corpuscles, they running or moving rapidly to and fro, but some few, stick to the glass slide and stay there; these are white corpuscles. Form and size, then, are peculiarly commonplace in the red corpuscle, the size in diameter being about 1-3200 of an inch to 1-200. They are larger in some people and smaller in others. At times a certain focus of the microscope displays a dark center, resembling a nucleus. The large ones are called *macrocytes* and the small ones *microcytes*. These bodies are about 1-800 of an inch thick; they have the power of changing slightly their shape, but they are so *elastic* that they readily return to their orig-

inal shape, unless the pressure has been great enough to rupture them.

There is no cell membrane to the corpuscle and it has no nucleus. Many drugs change the shape of the corpuscles, as chloroform, ether, and even electricity. When examined we notice some to be corrugated. Why is this? Because of evaporation? No. They may be older than the others and are nearing their time of decay or death. In a cubic millemeter (1-25 inch) of blood there are about 5,000,000 red corpuscles in man, and slightly less in woman, about 4,500,000. In the blood vessels they prefer and do keep in the centre, while the white keep close to the sides. In freshly drawn blood these red corpuscles form themselves into little rolls like coins, called *roleaux*. There are supposed to be about sixty billions in a man's body, and if placed side by side they would form a surface 80 paces square, and enough pass through the lungs every second to form a square 30 paces each way. There is a corpuscle found sometimes in the urine, known as the bean shaped, and it is caused by the acid reaction. Sp. gr. of the red corpuscle is 1110; they usually live about 4 or 6 weeks. Bile kills them quickly. They are 56% water and 44% solids.

Of what is a *red corpuscle* or "little body" composed? A *stroma* or skeleton, which is protoplasmic in structure, colorless, and is easily separated from the *haemoglobin* by placing it in water, which dissolves out haemoglobin, and we have resulting *laky* blood. Bile acts likewise, as seen in yellow fever, so also ether and alcohol. Freezing and thawing act in the same manner .

Stroma, then is protoplasmic, a kind of globulin.

Haemoglobin (*is composed*) of *haematin,* a coloring matter, and a proteid substance known as *globin. Haemoglobin,* with *stroma,* forms the red corpuscle. It is the great *oxygen-carrier* of the body, and gives *color* to the blood and other parts of the body.

Haematin contains *iron,* and thus oxygen and iron are carried through the body together.

Haemochromogen, formed from haemoglobin without oxygen's presence, is haemoglobin's most important con-

stituent; it takes up oxygen readily and forms haematin. Haemoglobin is crystallizable, and it can be plainly shown by using a rat's blood, it being less soluble than man's blood, and therefore more easily crystallized. In 100 parts of the red corpuscles of the human there are 90 parts haemoglobin.

FIG. 21.—*a*, Oval Corpuscles of a fowl. *b*, Corpuscles of a frog. *c*, Those of a shark.
The five small ones at the upper part of the figure, represent the human corpuscles magnified four hundred times.

Criminals have been caught by examining their clothes and recognizing the difference in *shape* and *size* of the man's corpuscles from that of other animals. Science may catch the guilty by examining the blood. Bile coloring matter is gotten from the dead red corpuscles. These corpuscles die all over the body, and are not destroyed exclusively in the liver and spleen, as previously imagined by some authors. Fresh blood if injected in an animal will live, but if kept a while or heated first it will die. If the blood to be used be kept on ice it will live. Haemoglobin is the great and only source of coloration in the body. The serum of an animal injected into the veins of an entirely different species will kill the red corpuscles of that animal. These red corpuscles vary markedly in the different animals, as is shown above. The spectroscope, an instrument used by astronomers, will detect these differences even if the solution to be examined contains only 1-1000 part of a grain of the coloring material of the corpuscle.

Where do these red corpuscles come from? The red marrow of the bones. They are also formed in other parts of the body in childhood, supposedly in the liver and spleen, and we find, too, that the red marrow of the bones is found in those places of the bones which, in adults, contain yellow marrow. In anemia we have a diminished number of red corpuscles, as in many other diseases attended with high fevers. Physiologically, a man may, by changing

his altitude from a low to a sudden high one, increase his red corpuscles. In *haemoglobinuria* the coloring matter is found in the urine, but no corpuscles are there. *Haematuria* means the passage of blood from the kidneys.

White Corpuscles. These bodies vary in number. One to 400 or 700 red corpuscles may be the proportion, yet they differ even at different hours of the day. They are as large, or larger, than the red corpuscle, and float along in the same plasma. In form they are globular; not smooth all over, but irregular; not flat, nor homogenious, but they have a nucleus or multi-nuclei, with a membrane surrounding each. They are *viscid,* which causes them to cleave to the sides of the vessels. They linger around an abrasion of the vessel and are the first found at an irritated part, or wound of any kind. Their sp. gr. is somewhat lower than that of the red corpuscle, which prevents them from precipitating so easily as the red. We find them changing their shape a number of times in 15 minutes, and also they have the power of passing through membranes, hence they are, therefore, found all over the body, not only in the blood vessels, but outside of the vessels. From the above description we conclude that they are minute bits of protoplasm, and they are, having the same functions and automaticity, and we call them "living matter.' They will rush to any point where mischief is going on, and will creep through the vessel's walls into the tissues and return when they like. They are, then, "emigrants."

Leucocytes, is a better name for them, because of their mobility and changes of position all over the body. When they die, they, with the tissues, form "pus." *Phagucytes* are supposed white corpuscles, which eat flesh and digest it. Some of the white cells wander around;, they are *hymphocites.* All white corpuscles are finely *granular,* and sometimes these granules *hide* the nucleus; but dilute acetic acid dissolves most of these granules and brings the nucleus into view. The diameter is about 1-3 greater than that of the red corpuscle, or something like 1-2400 inch. So small are they that in a single drop of blood hanging from a pin point we may estimate about 1,000,000 of these tiny little

bodies. A grain of sand is as if we compare one to a mountain, for we can *see* the *grain* of *sand,* but the corpuscle is *minute.* A single nuclear cell is called *mono-nuclear;* more than one, multi-unclear. They must destroy or produce a poison or ptomaine, which destroys bacteria, for if we place pus or bacteria in the tissues and leave unmolested a short time, and then examine them with a microscope, we will find numerous round-celled leucocytes, which have quickly pushed through the vessel walls and crept there from the outside, and are present to give battle to the "*invading army of germs.*" A scar is a "monument," so to speak "to the killed white corpuscles." Having fought, died, and in dying forming pus, which duly organizes and makes healthy granulating scar tissue, these scars being marks of distinction. Break a leucocyte up and we find that their nuclei pass into the blood; thus we get nucleo-albumen, or proteid. Red corpuscles are more rapidly *reproduced* than the white. Take the wounded men in the army; they were expected to rally and be on duty in a day or so because of the above fact. Frequently a slight loss of blood will produce a marked damage because the red corpuscles are *not* reproduced. Why is this? We do not know. Some *vital parts,* possibly, are *diseased,* and refuse to act. The *protectors* of the body are the white corpuscles. Under what *condition* do they *fight* and *protect* the tissues best? *Heat.* What condition in which micro-organisms work worst? *Heat.* So, in *inflammation, heat assists* the scavengers or white corpuscles. How is this shown? *Anthrax* will not affect the *fowl,* because its normal temperature is higher than ours, but *chill* the *fowl* and the anthrax will *kill* it. Within certain limits heat, or elevated temperature, does no harm then, it seems. The *heat* acts, so to speak, as the trumpet call to the ever ready *leucocytes.* What becomes of them? Many are destroyed in the blood-stream; others are killed or die while trying to eliminate the foreign body of whatever character of irritant it may be. *Where are they replaced?* In the *lymphatic glands;* they also *reproduce themselves,* and some writers say that the *spleen generates* many. They are found in *bone marrow* in small quan-

tities. Their *salts* are principally *potassium,* there being little sodium.

Plasma is the fluid in which the corpuscles float. It is difficult to separate, because of the clotting. *Sp. gr.* is 1010 to 1020; it is *straw-colored* and *alkaline* in reaction. Fibrinogen, Paraglobulin, Ferment, albumen, Na Cl, K Cl, Ca Cl and Mg Cl, the Phosphates and a great deal of water form principally the constituent elements of *Plasma.* What is the difference between *serum* and *Plasma?* The absence of Fibrinogen in *serum.* Therefore, *Plasma* will clot; *serum* will not. Plasma brings back Co2, fatty matter and moisture from tissues. *Fibrinogen* is found in Plasma, but has no nourishing properties. It is the important factor of *clotted blood.*

We also find *Paraglobulin* in Plasma in large amount, which may be the nourishing product of our bodies, as well as *serum* albumen, which is exclusively so considered by some, to be nourishing part of the blood.

Globulin, will not be held in solution in water, but is thrown down.

Fibrin Ferment is also a great factor in the formation of clot. Why do we have the *clot red?* Because the corpuscles are *caught* mechanically by the Fibrinogen formation and thus make the clot red.

Blood Plaques are small circular bodies, about one-half the size of a red corpuscle. They glisten and may be little corpuscles, some red, others white. As soon as blood is drawn they come together and soon form *fibrillae,* and thus they may have a great deal to do with the *fibrin* formation. The most important *salt* in the *corpuscles* is *K Cl;* in *Plasma, Na Cl.* Then for *solids* we have K Cl; for *fluids,* Na Cl.

COAGULATION OR CLOTTING OF BLOOD.

Three or four minutes after blood is drawn from *man,* it *clots.* *Horse blood* requires a longer time, while *bird* blood clots almost instantly. The first thing noticed is its viscidity and slow movement; then it begins to coagulate or solidify and take the impression of the vessel in

which it is drawn; then it will *contract* and draw itself from the sides of the vessel, and simultaneously to squeeze out a watery fluid, which is known as *serum*. This process continues until only a small clot is left in the centre of the mass. Horse blood if allowed to stand sometime, at a low temperature, it will not clot, but separates its contents; the lower strata consists principally of corpuscles, caught together mechanically, and the upper strata chiefly of plasma. Pour the upper strata off and *warm* to a given temperature and it will *clot*. Consequently, we deduct the fact that *corpuscles* are not necessary for clot formation, but just happen to be caught there by fibrin formation.

The "Buffy coat" or "citron coat" is nothing but the plasma clot, on the corpuscles. The white corpuscles are not found in large numbers in clot, but by their automatic-amoeboid movement they "creep out" and away from these "tightening fibrin lines." At first, blood coagulation is soft and jelly-like, but in a very few minutes it becomes firm and fibrin-like.

Why does blood clot?

Fibrinogen is the constituent factor of *fiber;* but if we obtain fibrinogen in a *free state* and make a solution of it, we will not produce a clot. *Nucleo-proteids* and *Lime Salts,* with the above *fibrinogen,* cause fermentation and a *clot.* The presence of *Paraglobulin* is not required. In order to get the *nucleo-proteids* necessary for clot the white corpuscles must decompose. Why does the clot look so *red?* Simply a mechanical catching of the red corpuscles in the net-like fibrinous strings. What are the fibrillae which hold them? *Fibrin,* a substance which makes up the bulk of the clot. It is a white elastic proteid substance, but does not exist as such in the blood. The above-mentioned *Fibrinogen* and *Nucleo-proteids* and *Salts, produce clot.*

If these substances exist in the circulation why do they not *clot?* They remain *separate* so long as in contact with *living tissue.* Injure the tissue internally by a ligature or force and a clot forms. This is our *safeguard* against *death* from hemorrhage or great loss of blood. We have a diseased condition which, on the slightest scratch or cut, bleed

profusely and continuously till death results. We call these cases "Bleeders;" they are scrofulous cases. Blood clots rapidly even in the infant vessel. Nature has well guarded the child against bleeding, for the vessel injured will soon plug its outlet and stop the hemorrhage. In the lower animals, as a safeguard blood clots much more rapidly, and we saw that bird's blood clotted almost instantly; so the more *helpful,* the *slower* the clot formation, and the more *helpless,* the more *instantaneous* the clot formation.

The Necessity of Blood is realized now, possibly, after having seen and learned from other sources, experimentally, its value. For it is our sheet anchor. Busy day and night *carrying nourishment to* and *bringing waste from* all our tissues found in the body, either directly or indirectly. It is, indeed, a *necessary internal* medium of value. The living tissue walls of the vessels prevent clot by contact.

HOW TO PREVENT CLOTTING OF BLOOD.

Sodium Chloride will prevent *clot.* If, then, the *salt blood* solution be *diluted,* the clotting will go on. The Na Cl prevents *blood decomposition,* and thus clot formation. *Cooling* blood to a certain temperature will prevent clot; but raising the temperature to normal will give it power to *clot again,* even though it has been frozen. *Menstrual blood* and also *capillary blood* are not supposed under any condition *to clot. Electric shock* prevents blood clot, if sufficient to kill the animal or man. *Whipping* blood and getting out the *fibrin,* and *Sulphate of Magnesium* will prevent clot; so will a solution of a *Leech's head* prevent blood clot. It is supposed to have some glands around its mouth which secrete a substance which prevents coagulation.

HOW TO PRODUCE CLOTTING OF BLOOD.

Keep at normal temperature of the body, warm and healthy. The *thymus gland* diluted and well dissolved, if injected into a rabbit, will cause its blood to clot. The same is said to be the property of some parts of the *brain.*

Blood.

- *Blood.*
  - Corpuscles
    - Red
      - Stroma
        - Globulin—which holds Hæmoglobin.
      - Hæmoglobin
        - Heamatin–iron carrier.
        - Globin—a proteid.
        - Oxygen-color carrier.
    - White —Protoplasm
  - Plasma
    - Fibrinogen.
    - (Paraglobulin.)
    - Nucleo-proteids and Lime Salts (Ferment Agents.)
    - Albumen
    - NaCl—KCl—MgCl and CaCl. and large amount of water.

Blood Plaque are considered as little corpuscles.
Serum is plasma minus *fibrinogen.*

- *Blood Clot.*
  - (Corpuscles) not necessary , mechanically caught.
  - (Paraglobulin) not necessary.
  - Fibrinogen, most important; *without it, no clot.*
  - Nucleo-proteid and salts (ferment); *without them, no clot.*

Plasma clots, lymph clots, but *serum* does not.

There are *two theories* as to important role of the blood *vessels with* regard to *clotting. One* is that the blood vessels *absorb* constantly from the blood a *substance* which prevents fibrin formation; the *other* is that *blood vessels* are *passive.* They do not *excite* the *blood* to *changes,* resulting into fibrin formation, while *foreign* bodies do, so also injuries.

CHAPTER X.

ANATOMY AND PHYSIOLOGY OF THE BLOOD VESSELS AND HEART.

Circulation. This is produced by the *contraction* of the *heart,* the *elasticity* of the *large vessels,* the *contractility* of the *small vessels,* the capillary resistance, the *action* of

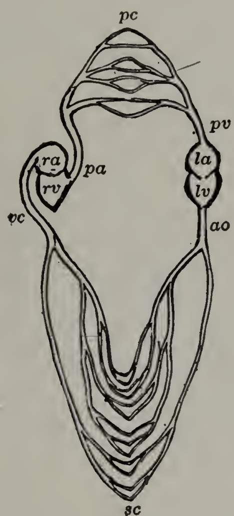


Fig. 22.—Diagram of the blood vascular system, showing that it forms a single closed circuit with two pumps in it, consisting of the right and left halves of the heart, which are represented separate in diagram. *ra* and *rv,* right auricle and ventricle; *la* and *lv,* left auricle and ventricle; *ao,* aorta; *sc,* systemic capillaries; *vc,* venæ cavæ; *pa,* pulmonary artery; *pc,* pulmonary capillaries; *pv,* pulmonary veins.

our *muscles,* and the *influences* brought to bear by normal *respiration,* expansion and contraction.

The *heart keeps* the large *vessels overfull,* the *elastic large vessels squeeze* the *blood* down to the *smaller* vessels, the *contractility* of these *smaller vessels forces* it through

the *capillaries,* the *capillaries offer resistance,* the *muscular action helps the veins* to *return* the blood from the *capillaries* to the *heart,* and the *expansion* of the *chest* and *lungs sucks,* so to speak, the *returning blood* to the *heart.* The heart acts as an intermediate organ, sending and receiving continuously. We need a regular systematic flow of blood through the body. Yet while it is steady in character, the supply must necessarily be varied, giving little to the resting muscle or organ, and freely supplying the highly active muscle or organ. *Activity,* means large supply of blood; *rest,* means simply enough to nourish the structure and *repair* its damaged tissue. *Tension* is the amount of pressure exerted by the arteries on the blood.

Transfusion or transferring blood from one living animal to another by injecting it into the blood vessels of its body. It is frequently done in case of great loss of blood from accidents and wasting diseases.

It is said that a dog, old, lank and deaf from old age had these defects actively restored to him by the injection into his veins of blood taken from a *young dog.* Also, that a horse, 26 years old, having four lambs' blood injected into its veins, acquired new life and strength. One said that even a *dead animal* was revived and made able to stand and make some regular movements by this method of *transfusion.* Man, too, is greatly benefited by this method, and soon after Harvey's discovery of the "Circulation of the Blood," it was quite a fad among the elite of the country, thinking it a panacea for all ills. However, the Pope interdicted it, so also did the government. The serum or plasma is not the *reviving* part, but the corpuscles seem to have the vitalizing agents.

By placing Mercury in a test tube the Blood Pressure will lift Hg up 6 in. in left ventricle, 4 in. in right ventricle, and 3/4 in. in auricles.

Color Changes of Blood. In passing through the body, blood changes its color from a *bright red* to a *dark red.* This is caused by its circuit, and by its giving up *Oxygen* and *iron* and *coloring matter* to the tissues, and taking back in return the waste, Co2, *fatty matter* and *moisture.*

Red blood is *arterial; dark blood* is venous. *Quacks* speak of *purifying* the *blood,* and thus fool the people. *Regular exercise* is better than *random physic or pills.* It *invigorates* every *organ* and *tissue.*

THE HEART.

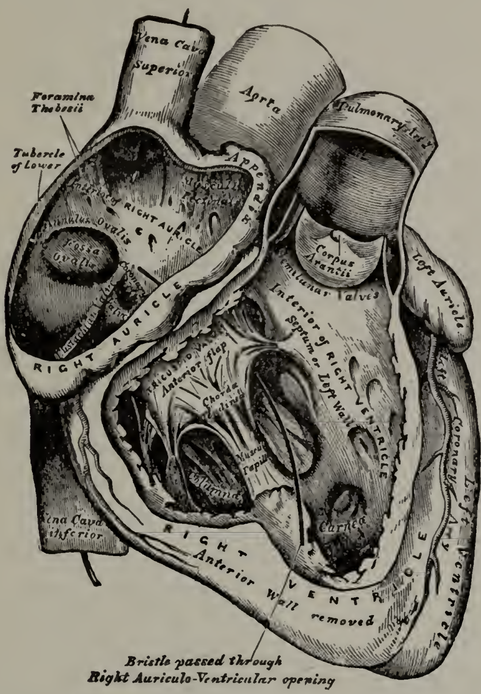


FIG. 23.—The right auricle and ventricle laid open, the anterior walls both being removed.

The Heart is our supply organ; it is an enlarged part of the vascular system. Muscular, highly supplied with nervous influences and arterial blood, it acts as the *pump* which *overfills* the large elastic arteries running from its thick, hollow cavities. Some call it the *central engine.*

Between the third and sixth ribs, behind the breast bone (sternum), and obliquely placed with its *base* upward and toward the right, and the *apex* downward and toward

the left, we find this little *pear-shaped,* wonderful organ residing and forcing the current of blood into the circulation. Sleepless and tireless it continues, day and night, working while we play, sleep or eat. Between the fifth and sixth ribs we may, on the left side, near the nipple, feel its *beat* and feel its *force.*

The apex is freely movable; the base is fixed to the centre of the *diaphragm* by the inferior vena cava. It also rests on the diaphragm. The heart, to prevent loss of power by friction, is enclosed between two layers of membrane, serous in character (with a tough outer fibrous layer), and sac-like in formation. It is called the *pericardium* (surrounding the heart), and is especially smooth and shiny. To keep itself in this easy, freely movable condition it secretes a fluid of rare quality, which lubricates its whole surface. The *endocardium* is the inside lining of the cavities of the heart, for the same free movable purpose as the outside covering or pericardium.

The *heart,* is, then, a hollow muscular organ having four chambers. Two at its *apex* and two at its *base.* It is conical in shape, 5 inches long 3½ inches wide and 2½ inches thick. The *apex* or point is rounded and blunt, the *base* is irregular, being formed principally by large vessels, and the two thin cavities, *auricles.* The anterior surface is convex or rounded, the posterior surface is flattened, being upon the diaphragm. The right and left borders are not sharp, but rounded. In weight it averages 8-10 oz. in man, 7-9 in woman. The muscles are striated fibre, held together by sticky connective tissue, and has no sorcolemma, thus differing from skeleton muscles. These fibres are made up of peculiar quadrilateral cells with nuclei, which freely communicate with other cells of the same region. Arteries run from the heart, veins run toward the heart, the former laden with arterial blood, the latter with venous blood.

The Heart Cavities. The two forming the apex and the thick part of the heart are called *ventricles* (*bellies*); the two forming the base are called *auricles,* because of the fancied resemblance to a dog's *ear.*

The blood supply is from the right and left coronary arteries, which supply the muscles direct, giving the first and richest blood to them. The nerve supply is from the pneumogastric and sympathetic system; but the heart muscles have an inherent power of their own, and will contract,

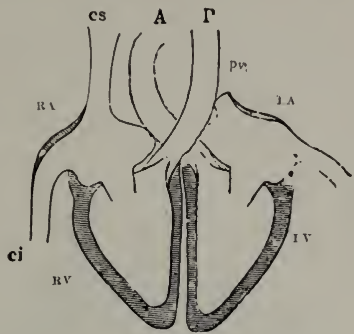


FIG. 21.

A, Aorta. P, Pulmonary artery. ci, Inferior vena cava. cs. Superior vena cava. pv, Pulmonary veins. RA, Right auricle. RV, Right ventricle. LA, Left auricle. LV, Left ventricle.

after separating from the body of a *frog* or other cold-blooded animal. You may even cut it up into bits and still it will rhythmically contract and relax. We will further speak of the nerve influence on the heart later.

The right ventricle forms the bulk of the external surface of the heart, and the left ventricle forms the principal part of the posterior and flattened surface.

The two auricles are both thin in structure, while the walls of the ventricles are unequal in thickness. The *left* being three times as thick as the right. The reason is, the *right* only pumps the blood into the *small* or *pulmonary circulation,* and the *left* pumps the blood over the whole body, or *systemic circulation.*

An auricle and ventricle communicate with each other on the *same side*, but not from *side to side,* except in the fœtus. The right half of the heart is for venous blood, the left for arterial blood.

The *veins* empty into the *auricles,* and the *arteries* commence from the *ventricles.* Therefore, each chamber or cavity of the heart has one or more vessels either *running to* or *from* it.

The auricles are *thin*-walled, and have muscle fibres running from side to side, and from before back, like our suspenders. But they are not firmly attached to the ventricles, only by a kind of glue which may be dissolved by thorough boiling, when you can easily pull the auricle apart from the ventricle. The auricles fill with the blood first, then contract and overfill or distent and force in more blood into the ventricular cavity, which partly fills as the auricles do. But its walls being so much thicker than the auricles that it takes the *force* of the *auricular contraction* to *distend* and completely fill it.

The openings into the right auricle are the auriculo-ventricular, the Venæ Cavæ ascendens and descendens,

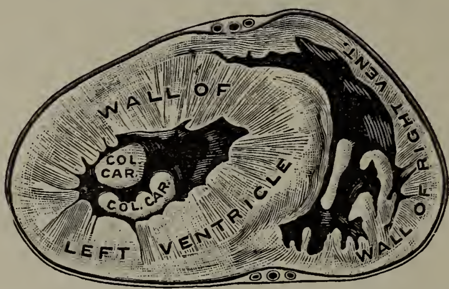


Fig. 25.—Cross-section through both ventricles, showing the shape of their cavities and the relative thickness of their walls. (Testut.)

the coronary sinus and venae Thebesii (very small veins which come, like the coronary, from the substance of the heart).

The auricles have a *sinus*, or large opening, which is smooth; and a small rough appendix called *auricular.*

The left auricle has four pulmonary veins, which come from the capillaries of the lungs, and bring *arterial* or *oxygenated* blood which is red. This is an *exception to the rule,* as arterial or red blood should pass through *arteries* and not through veins. We find another case reversing these laws similarly, in the *foetus circulation*, and also in the *pulmonary* artery. In this auricle the auriculo-ventricular opening of the left side also communicates with it.

These two, right and left, auriculo-ventricular openings have *valves* guarding them. The right one, tricuspid, has

three *flaps* or *cusps*, and the left one, mitral, has two *flaps* or *cusps* guarding it. These are to prevent any more blood getting into the ventricle than is *needed*. They hang down like a curtain from the fibrous ring, and have *little cords, chordae tendinae,* attached both to their free borders and running down to be secured or fastened to the walls of the ventricles. Thus, the little muscle attachment on the walls of the ventricle can and do *contract* and *relax,* and thereby regulate the closing and opening of this *valve,* as the nervous influence dictates.

The auricles hold about two ounces of blood. Its action is quick and sharp, and then it immediately relaxes; it contracts in about 1-10 second; the ventricle takes 3-10 second, and it takes about 4-10 of a second to *pause*.

In the *ventricle* we find a *thick wall* for *pumping purposes*. Its muscles are seven in number and very complicated. The last, or vortex, curls around the heart from its base (of ventricle) to its apex. This causes the heart to twist on itself and turn toward the *right* in contraction. Each ventricular floor or wall internally is made of columnæ cornæ, little fleshy columns. *Systole* means *contraction; diastole, relaxation.* The valves guarding the arteries from the right and left ventricles are semi-lunar in shape and are very tightly adjusted, so that regurgitation or back flow of blood is rare. In the valves between the auricles and ventricles we have often a back flow of blood, with little danger attending the phenomenon. In such cases as pneumonia we have this back flow, and it is helpful, the inferior venae cavae acting as a reservoir. Frequently diseased valves will allow regurgitation. At the *beginning* of the pulmonary artery (which takes venous blood to the lungs to be aerated) and the aorta (which takes arterial blood all over the body), we have a dilatation or pouch, called the *sinus of Valsalva,* which allows the *semi-lunar* valves to fit, without friction, to the passing blood, forced through by the ventricles. The *Veins* have no valves as they enter the auricles, but at some distance away from the heart we find valves which hold the weight or column of pressing blood, to prevent sagging or pouching of the venous walls in their long courses through the body. The ventricles hold each about two

ounces of blood, the auricles the same. None of these cavities are ever empty. They may be full to their extreme capacity, or one-half full, but they are always filled, no space being *left unoccupied* by blood. The *heart muscle* is peculiar in that it takes on fatty degeneration with such ease, and more singular still is the ease with which it is restored to health.

The wave of contraction begins in the *venae cavae,* then reaches the *auricles,* and finally the *ventricles,* all accomplished in a short, quick manner. In muscles generally you *can contract* them by *stimulus* and *hold* them so; you cannot do so with the heart. It will relax in spite of stimulus.

Rhythmical contraction of the heart is due to some inherent protoplasmic power of its cells. The nerves, of course influence this rhythm, as they do every other movement or act of the structures of the body. The heart muscle has *tone* as well as any other muscle, and it may vary at different times. When the *ventricles contract* the *auriculo-ventricular* valves *close,* and the *semi-lunar* ones open, and vice versa. What happens during the *pause?* The *auricles fill from the* venae cavae and pulmonary veins. What is the *condition of the ventricles* at this time? *They* are also *filling* from the auricles, but it takes the auricular *contraction* to fill them sufficiently. Do the auricles empty themselves in doing this? No. They only send enough to *completely fill* the partially filled ventricles, and then begin to fill again, thus they *always* are *filled before* the *ventricles.*

In the aquatic animals which stay long under the water we find enlarged venae cavae, which act as reservoirs when the blood is pushed *backward,* instead of *forward.* When excited the heart throws out less blood than normal, but much more rapidly. Ordinarily, the *heart cycle* is systole of auricles, 1-10; of ventricles, 3-10; the pause, 4-10 or 5-10, and relaxation, 1-10. Different teachers have this cycle somewhat changed. The blood hesitates before leaving the ventricle, because it has to *overcome* the *resistance* offered by the blood in the *aorta.* Each heart is found to be divided by a *septum* into halves, as we have described. The right half is venous, the left arterial. To get to the opposite side

the blood must pass through a set of capillaries, as shown on page 69. The aorta comes from the left ventricle, the pulmonary artery from the right.

The *will* is not required to regulate the heart's action, and great indeed is this advantage. For if it depended upon us to will each movement of the heart, our entire attention would be taken and we would have no time left to read, sleep and have pleasure. It is estimated that the heart, in repose, rests about 9 hours a day.

Blood Passing Through the Heart. Venous blood enters the right auricle, passes through the tricuspid valves, enters the right ventricle, is forced through the semi-lunar valves into the pulmonary vessel, thence it goes through the lung capillaries (giving up the carbonic acid gas, fatty matter and moisture) all, waste products of the body, and taking up oxygen, is now collected by the pulmonary veins (arterialized blood now) and emptied into the left auricle, from there, through the left bicuspid valve to the left ventricle, and lastly it is forced through the semi-lunar valves of the aorta into the aorta and thence over the whole body, being later collected by the veins, beginning from the capillaries and getting larger until they terminate into two large ascending and descending venae cavae, which empty into the right auricle again. A continuous circuit, about 72 times a minute, day and night The *arteries* carrying the nourishing material and the *veins* bringing back the waste products, the *capillaries* acting as the delivery and collection agency. The heart is the central force pump, which overfills the arteries. Disease, joy, grief, over-excitement and exhaustion, with many other agents, affect this mechanism daily, and may cause great damage if to excess.

In early life our pulse is from 90 to 130 in a minute. In one hour, then, our hearts beat four thousand times. If we estimate the amount passed every systole at 4 oz., we move about 12 tons of blood during the 24 hours. We can now understand how perfect the vital heart machine is. The ancients imagined it the resting place of the *soul,* and Shakespeare speaks of the soul as being found in the *liver* The many words we use today, as *courage,*

hearty, etc., show how it has been passed on to us. No machine is so perfect today, for the heart not only works cleverly, but it repairs its own waste, it lubricates its own action and it regulates its own movements according to our body needs. It is, indeed, a wonderful little vital pump.

Sounds of the Heart. Only two. The *first* is a prolonged sort of roaring or humming sound. It commences with the beginning of the ventricular systole. What causes it? The muscular systole and the auricular valves flapping back. Can hear at the apex of the heart.

The *second* sound is short, sharp, clicking together of valves. What valves? The semi-lunar valves.

Professor Miles is the authority for saying that the venae cavae are *open* during systole. He says that they are open and ready to receive any regurgitation of blood which may be forced back, and thus save the strain on the heart during excessive exercise or work. Also that the auriculo-ventricular valves are *never* entirely closed during systole.

THE ARTERIES.

The heart, by its systole, forces about four ounces of blood into the large arteries. It then relaxes and rests. Then contracts again, etc. But what would become of our perfect circulation if there were nine hours' rest and stopping of circulating fluids in our vessels? When the heart *rests* the *large elastic* arteries press and squeeze the column of blood over the whole area of the body. The *heart starts* circulation, the *arteries* keep it going, here, there and everywhere, to supply the needs of the tissues. Arteries are musculo-membranous tubes leading from the heart, to varied and distant parts of the system, passing upward and downward and laterally.

Arteries are composed of *three coats*. The *intima,* the *media* and the *adventitia.*

The *intima* is a very thin coat composed of a layer of living endothelial cells, placed edge to edge on a basement membrane, and an internal elastic membrane or tissue.

The *media* is composed of elastic and muscular tissue cells, nucleated, and they wrap around the vessel. In the large *arteries* the elastic tissue is in excess, and in the smaller size the muscular is in excess. This elastic tissue is of the yellow elastic tissue variety.

The *adventitia* is found on the outside of the artery and is composed of connective tissue, which connects it to the other tissues of the body, surrounding it.

The tunica intima, by its vital activity, may prevent blood-clotting in the arteries. The large arteries are *elastic*, but not *contractile*, as the smaller ones *are*, although they are slightly elastic, too; the larger, the more elastic, the *smaller*, the more *contractile*.

Blood Pressure, we saw, was due to the vessels always being full. It also varies. If we increase the blood flow we have tension and *blood pressure;* decrease the blood flow and pressure is decreased. When the heart is strong and full, pressure is increased; weaken the heart and the pressure is decreased accordingly.

As the blood spreads out over a large area the current becomes slower, and consequently the pressure is reduced.

The Greeks supposed these vessels to contain *air*, and hence the word *artery*. Cicero speaks of the arteries as "conveying the breath to all parts of the body." Shakespeare referred to "the ceded heart, tapping at the chest wall!" in Macbeth.

Pulse. With each systole of the left ventricle the impulse causes a wave-like motion to traverse the walls of the whole arterial system. This is done in about 1-6 of a second. Generally the arteries run away from the surface of the body and keep toward the deeper structures. This is nature's way of protecting these tubes from injury and exposure to different sudden temperatures. They keep close to the bones and under muscles, some even being protected by bony cavities, as in the *skull, thorax* and *pelvis*. In some cases, as in the wrist, temple or crossing the lower jaw, we find them near the surface If we feel these vessels, we recognize a throbbing motion, keeping in harmony with the heart. This is the *pulse-wave*. The blood goes

faster than the pulse wave. Some say that the blood moves at the rate of 26 feet per second, ordinarily. It is supposed to go around the whole circulation in 30 seconds. A diacrotic pulse is one in which there is a diseased disturbance which causes a second *wave,* which is higher than the first or more natural one.

From experiments with animals, it has been concluded that the pulse of a lion beats 40 times; that of a tiger, 96; of a horse, 40; of a wolf, 45; of a fox, 43; of a bear, 38; of a monkey, 48; of an eagle, 160; of a butterfly 60 times in a minute. The elephant pulse could not be determined.

CAPILLARIES.

The arteries become smaller and smaller as they get farther from the heart, and finally they cannot be traced except by the use of the microscope; these terminate into the *capillary* vessels. The word meaning *hair-like,* from the Latin *capillaris.* These are extremely small and fine vessels, even much smaller than a *hair, having* a diameter of about 1-3000 to 1-2000 of an inch. These vessels are the means of connection between the arteries and veins. The average distance is about 1-50 to 1-25 of an inch between the two. From this we conclude that only two or three corpuscles can pass through abreast, and frequently only one. They are so close that a pin's point could not be inserted between two of them. While flowing in these delicate tubes the blood does its nutritive work, the arteries really being supply-tubes for the capillaries. Harvey failed to account for the presence of these small vessels, and it was the one fact lacking to complete his important discovery of blood circulation. By the aid of the microscope, and Malpighi, in 1661, somewhat later, these vessels were discovered and described.

The *motion* of the capillaries is peculiar They contract, dilate and sway, sometimes allowing the corpuscles through in single file, sometimes three abreast, then you notice the tube vacant, without a corpuscle; again, we notice the few corpuscles turned aside or pushed back, seemingly, till at last, after giving up and collecting all necessary

and unnecessary matters, the corpuscles pass on into the small veins and eventually reach the heart again. Blood takes about one-half to one second, to pass through capillaries. These marvellously interesting physiological experiments are well shown in a frog's foot or web, magnified about 30 diameters. These vessels, then, are *elastic*. If you get a cinder in the eye it becomes, although previously white, very red and blood-shot. This is a dilation of the capillaries, enormously distended. A blush is an example of the same character, except that the cause or stimulus comes, not from a foreign body, but from the nerve centres, which cause some transient pleasure or pain. In drunkards we see the chronic or permanent distension of the capillaries over the nose, which may become purple from blood stasis.

FIG. 26.—Margin of frog's web, magnified thirty diameters. Showing corpuscles in vessels. *a*, Artery. *v*, Vein.

Assimilation is the carrying of nutriment to each individual organ or cell over the whole body to the bone, muscle, skin and brain, as required by the dictates of nature. Most animals have the power to repair their own tissues, but some have that power to a remarkable degree. *Man* has bone and skin readily, if injured, renewed and built up strong and firm. The *lizard,* if its tail is cut off, can grow another; crabs grow new claws if they lose one or more from injury. It is also said that water lizards have the power of restoring an entire eye or part of the head may be completely renewed. There are numerous earth worms which have the power of restoring portions of their bodies completely. Man, then, is more able to attend his *injuries* than the lower animal; therefore, they have a greater assimilative power to individual parts than man. Sleep is the important period of the child's assimilation of its food, and that should be quiet, undisturbed sleep. The aggregate caliber of the capillaries is from 400 to 800 times that of the aorta.

What makes the white welt from a blow? Effusion into the tissues and pressure upon the capillaries. Brains

that are most congested in life may be the whitest after death for the same reason of effusion into the tissues of fluid which presses upon the capillaries and pushes back any blood that may be in their walls.

VEINS.

The vessels which return the blood from these capillaries are the veins. They begin as very small tubes and get larger as they near the heart. They enlarge as the tiny stream running toward one larger stream.

In structure they are similar to the arteries, yet not so elastic; but they are more numerous. They are especially distinguished from arteries, in the presence of *valves* all along their course. If long and downward in course, they have numerous valves. They are small folds of membrane, so constructed that they allow the current to flow toward the heart, but not in the reverse direction. If we tie an extremity, hand or foot near either, in a few moments the veins will be seen to enlarge, and on closer inspection we notice *little knots* at intervals of about one inch. These are the *valves.* Most veins are superficial, while the arteries are deep behind the bones, muscles, etc., for protection.

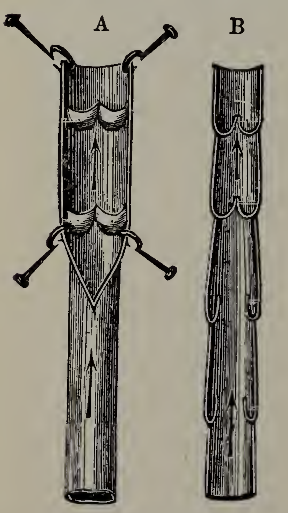


FIG. 27.—Valves of veins. A shows a vein cut open between the segments of two valves. B shows appearance of valves closed and open. (Testut.)

Being *inelastic,* veins need muscular exercise to assist them in pushing their contents more quickly toward the heart; therefore, open-air exercise, walking, running and all athletic movements, not to excess, assist markedly, venous circulation. Venous congestion, or lack of correct exercise usually causes dyspepsia and a large number of kindred stomach and bowel affections.

The portal vein is a very large and yet short vein, which receives the blood from the stomach, spleen, pancreas, and small and large intestines, and delivers it to the liver for certain chemical changes. This is called the *portal system.* Of course, the veins follow the course of the arteries, and are ordinarily two veins to one artery. The superior venae cavae collects all the blood from the head, neck, shoulder and upper extremity; the inferior venae cavae collects or receives the blood from the lower extremity beginning with the veins of the feet, and on up to the right inferior portion of the auricle, where it ends.

The Pulmonary *veins,* which bring the blood from lung tissues, bring *arterial* or *oxyginated* blood; the pulmonary *arteries,* which take the blood from the right ventricle to the lungs, takes *venous* blood. These are exceptions to the rule, for arteries usually take arterial, and veins, venous blood throughout the system.

NERVES OF THE HEART AND VESSELS.

Why *does* the *heart* contract? Not on account of *life,* nor *pressure of blood,* because you have seen it contract long after death. And the *ventricles* and *auricles* contract even after separation, and also after having been cut into tiny pieces. (This refers to frog's heart).

We must have *co-ordination* in the action of both *heart* and *vessels,* or else the flow through the *capillaries* will be *irregular,* and hence *nourishment* would be *deficient,* and *waste* would *poison* our system by *non-removal.* This *co-ordination*, then, between *heart and vessels* is most important and highly necessary for our welfare.

Do the nerves, running to the heart, cause its rythmical contraction? No. We have heard Dr. Miles say that he saw a man's heart auricle beat three hours after he had been hung. We have also cut the alligator's heart loose from its attachments, then cut it up into bits, and these small pieces of heart tissue have still rythmical beat Wonderful it may seem, yet it is true. It has further been proven that the *embryonic heart* will contract rythmically *before* the *nerve*

fibres enter its structure. We conclude, then, that the heart has an *inherent power* of its own; its muscles are specially endowed cells.

The ventricle, if stimulated, will contract *before* the *auricle.* Separate them and they can be made to contract at different times or rates of speed. Plainly, this demonstrates that the *ventricle* does *not depend* upon the auricle contraction. These are well-known facts, but the *nerve influences,* distributed through its structure, *modifies* the heart beat; then both the *inherent power* and nerves act.

Stimulation of the heart action may be by nourishment applied directly, as a weak solution of salt poured in through a glass tube, will cause the heart to beat more rapidly. *Blood, serum, albuminous fluids,* some *mineral* substances, calcium *Phosphates,* sodium salts from serum, are admirable heart stimulents. The heart may go into absolute Rigor Mortis and blood poured in will stimulate you. Potassium salts have an opposite effect. Bile, too, retards its beat, by making it weak and slow.

INHIBITION OF THE HEART.

The heart beat is kept up by its *intrinsic ganglia,* and its force and rate of beat is regulated by the pneumogastric and sympathetic nerves.

The *pneumogastric nerve,* which supplies the heart with the sympathetic nerves, if *stimulated,* will cause the heart to *beat slower,* and if powerfully stimulated it will stop beating. But we always find it stopping in *diastole;* this seems to prove that we cannot *tetanize* a heart.

Remove the stimulation and the heart begins to slowly contract again and continues rythmically to contract as though nothing had occurred to completely stop it. The auricle receives the stimulus *first,* and it is greatly influenced by it. What is this *stopping* or *slowing* of the *heart called? Inhibition.* How is it done? By *stimulating* the *pneumogastric nerve.* Can you inhibit it long? No. Only a short time. Where is this inhibition centre? We *find* it in the *floor* of the *fourth* ventricle. It is, then, the *cardia-inhibitory-center. Pressure* upon these nerves may cause inhibi-

tion. In the East, jugglers practice "dying while alive" by pressing these nerves against the transverse process of the sixth cervical vertebra. *Tapping* upon the *intestines* will produce the same effect. Our complicated cases of *indigestion* and *peritonitis* may thus *cause* the *excitement* and *palpitation* of the heart. Any sudden excitement of joy, pain, odor and sight may produce fainting and, reflexly, inhibition of the heart. How do these peripheral excitors get to the pneumogastric nerves? The influence goes to the Medulla Oblongata and the pneumogastric nerves originate in its substance, so that the *point* where these *influences* are *received and sent out* is called the *cardio-inhibitory center.* When does this centre act upon the heart? Perhaps at all times, slightly. What is the effect of cutting the Pneumogastric Nerves? The check rein is thrown off and the *heart beats faster.* (Cut one, no effect). Fainting, is heart inhibition *Inhibition* may be *inhibited* or counteracted by *drinking water* or by *mashing* the *testicle. Gland* secretion may be inhibited. We find this in some young "orators;" they are more apt to want *saliva* than *ideas,* on the stage. Stage fright may, then, be gland inhibition, resulting in a *dry tongue,* but not in wanting rich ideas or thoughts.

We sometimes *pinch* ourselves to keep from fainting; *swallowing* acts same *way.*

What, then, do we mean by *heart inhibition?* We mean the *condition* in which it *retains all its powers,* but does not act. It remains passive, holding its power in abeyance.

ACCELERATOR NERVES.

These nerves augment or quicken the rhythm of the heart; but we cannot say that they quicken the heart-action by *stimulation* of the *accelerators,* or by *inhibiting* the *inhibitors.* Thus we meet a difficulty in our proof.

The *sympathetic* and *spinal nerves* are the great *augmentors.* Their *center* is in the *spinal cord* and along the spinal column, especially about the *neck* and *chest* There are also sympathetic centers. These nerves increase the work of the heart, not *regardless* of the *inhibitors,* but both

the *accelerators* and *inhibitors* act at the *same time,* modifying each other's action. The *inhibitors,* holding back slightly the heart's action, while the *accelerators* spur it on, both, however, acting in harmony. Just as we *hold* the *reins* of a *horse* and steady him, while we touch or *spur him* on without *irritating* him. The *reins* act as the *inhibitors,* the *spur* or whip as the *accelerators.* The heart nerves end in cells and muscles.

A Catabolic nerve is one which *accelerates* and thus breaks down tissue by the increased contraction or movements of the heart, while a nerve which *checks* motion is an *Anabolic nerve.* It helps the organ to repair its *tired* or injured tissue by thus holding it in check. Thus the *Catabolic nerve* or *Sympathetic,* is one which breaks down tissue, and the *Anabolic* nerve or *pneumogastric,* builds up tissue. Which is destructive? *Catabolic.* Which constructive? *Anabolic.*

Sometimes electric stimuli will not *inhibit* the pneumogastric nerve center. Example: Take a frog and apply a solution of atropia; it cannot be inhibited or stopped. Now apply Pilocarpin solution; it quickly regains its normal state, and can be inhibited. Common sensation may prevent the inhibitory center from acting, as pulling the hair to prevent fainting, or riding horseback in war times to check fainting from loss of blood.

Blood Distribution is, and should be, for economies' sake, unequally distributed to all parts of the body. For a working muscle or organ requires more blood than a resting one.

The Vaso-Motor-System regulates this supply. The *small* arteries which deliver the blood directly to the capillaries, we learned, had muscular fibres and could contract; these are called *delivery* arteries. They are supplied with nerves and have tonicity, as any other muscle Thus they can by nerve stimulation *contract* or get smaller, or they can *dilate* or get *larger.* The one, *limits* the supply, the other, *overfills* the vessels or organs. They are constantly in a mild state of tone or contraction. Example: Cut the sympathetic of a rabbit ear; it blushes, or the vessels dilate. Stimulate

the cut end and the ear gets pale; vessels contract. Many experiments show this clearly. By cutting a cat's sciatic nerve, the ball of the foot acts in the same way. So that a man's pale face may come from stimulation of the nerves; or he blushes if the nerve influence is removed. This center is called the *Vaso-Motor-Center.* If this influence is removed from all the arteries, what occurs? All dilate, and we die, for we have not enough blood for the whole system of vessels at the same time. The blood may, by passing through this center, stimulate it by oxyginated blood, or inhibit it by carbonated blood, or by poisons found in the blood itself.

Blister-plasters, cups and counter irritation of some kind act not by drawing away the blood, but by acting on the vaso-motor system, and it oversees and directs the calibre of the vessels. Do we know how the blister will act? No. We only tell by experience. Cold causes, through the vaso-motors, palor. If animals are forced to inhale Co2 this inhibition is seen. The great splanchnic are the longest and most potent vaso-motor nerves. They preside over the stomach, intestines, etc. Where is this center? In the Medulla Oblongata and floor of 4th ventricle about 1-10 in. below the Corpora Quadrigemina. Strychnia and Calabar Bean will stimulate this center, and it is owing to this that we find the veins always full and the arteries always empty of blood after death; the venous blood stimulates the arteries to force the blood out.

Name the *constrictor* vaso-motors. The *Sympathetics.* name the *dilators.* The Chorda Tympani, nervi irrigentes and others. The skin does not seem to have vaso-dilators.

These centers can be *inhibited,* just as the heart centers can be inhibited. The vaso-dilators only act when they are stimulated, but the vaso-constrictors are acting all the time. There are nerves containing both dilator and constrictor fibres, which are seen when the sciatic nerve of a cat is cut and experimented with. At first it dilates; after a few days left alone it regains its normal power, and by stimulating, it *dilates* again, when ordinarily it should contract.

Pressor nerves are supposed to excite the vaso-constrictors frequently by being stimulated themselves.

Depressor nerves are, by their stimulation, supposed to excite the dilators. Loud talking and excitement will stimulate the center, and to a degree, prevent hemorrhage. This explains why our heroes bleed so little when wounded; this is caused by the action of the *Pressor* nerves. Put an animal under the influence of stimulation and you have a *contracting* of vessels; now administer chloral and stimulate the center, and the vessels *dilate* As a rule, when the arteries of the skin are contracted, those of the mucous membrane are dilated, and vice versa. In a chill, there is a vaso-constriction of the skin arteries, while the mucous membrane arteries are highly dilated. After a short time the pressure of the blood, forced internally, may act upon the depressor nerves, and thus inhibit the center. Hence, we then have dilation and "fever,' which is really a cooling off process.

Cutting through the spinal cord will cause all the vessels in the body to dilate. Later, if the peripheral nerve ends be stimulated they contract the vessels again. The sympathetics act as the vaso-motor center in the latter case.

In hyperaemia of the brain we give nitroglycerine. Why? It dilates all the vessels. How is the case improved? It dilates *all* the vessels and thus draws the blood away from the brain. Likewise we draw the blood from a *bleeding lung* by giving *assafoetida* to nauseate and *dilate* the vessels of the stomach and intestines. All of these different changes of vessel motion are presided over and governed by the nervous system.

THE HEART VS. ALCOHOL AND TOBACCO.

Alcohol is used commonly as beer, whisky, ale, port, brandy, etc. The early symptoms of a dose or drink of alcohol are frequent heart beats, flushing of the face, general feeling of vigor and great strength, warm feeling within and a blush or general glow externally, and in short a marked increase in vitality, *seemingly*. It makes you feel as if a stimulant like a spur has been used. A whip, to push on tired nature. Thus, instead of increasing strength and energy, it expends or uses needed force for its own expulsion

from the system without adequate return. Therefore, strength and force are lost, and false energy temporarily gained. True it is then, that "Wine is a mocker."

The heart's period of rest is shortened, while the force and number of the heart's beats are increased materially. If the heart's rest and pause period is shortened, then, naturally, the heart's *nutrition* is curtailed and injured. Dr. Parkes said "that the extra work of the heart, when stimulated by alcohol, was equal to the lifting of 15.10 tons one foot daily; and in two days 24 tons in excess of the regular work." He has known "one glass of liquor to cause 8,000 extra heart beats, which is equivalent to lifting 9 tons one foot high." This, of course, means unnecessary labor and fatigue for the active, ever-ready heart tissue.

Does alcohol cause exhaustion? Yes. The heart is easily excited by alcohol in all its forms It never becomes accustomed to its use, and we know that each drink causes renewed quickening and irregular pulsations of the heart. What is the result? *Exhaustion.* Not force or energy stored up, but *overwork.* This means tissue-destroyed and loss of vitality. We little know the strain that habitual drinking forces upon the heart muscles. It wears the organs out, yet we know that the heart structure is of the finest and best material; therefore, we live on, when otherwise we would collapse early in the habit.

Fat and Alcohol. Does drink increase fat? It is said that alcohol makes you "fleshy," and may diminish waste. This is true, but the fat is not firm; it is "bloaty," easily broken down in disease or labor. Inaction or sluggishness or sleepiness is caused by drink and they produce fat by this inertness. To fatten a goose you tack its feet to the floor of the coop and give the best food possible; its fat-producing power is, then, a false and unhealthy fat. Fatty degeneration in the human, means a deposit of fat in and between the muscles, and it is a serious complication in disease. It may be in the heart muscle; then we have a very serious trouble to deal with, for of all muscles, we need strength and power in the heart more than all others. When this is the case the blood undergoes a fatty change, too, which renders it incapable

of fully nourishing our bodies. In fever cases we readily notice the frequency of the mortality in drinking men. They have *weak hearts* from drink, and they easily fall a prey to epidemics and high fevers.

Tobacco vs. Heart Tissue. Tobacco often causes dyspepsia of the stomach, palpitation, irregular beat of the heart, or we call it a "throbbing" or "heaving" sensation. In some, it amounts to great distress about the heart region and stomach. Its use quickens the heart action and weakens it at the same time. These effects will cause a man to feel inert, tired and nervous, thus making him less able to attend to business. Do we not remember our "first chew or smoke?" We felt like dying from distress about the head, heart and stomach. It *poisoned* these organs.

CHAPTER XI.

THE NERVOUS SYSTEM, BRAIN AND CORD—SPINAL NERVES AND SYMPATHETIC NERVES.

Animal and Vegetable Kingdoms. We have studied about the circulatory apparatus and found wonderfully formed structures, performing phenomenal, mysterious functions. We have many other systems to study equally mysterious and complex. These are functions performed by *vegetables* as well as *animals.* The plant can grow, blossom, develop, bear fruit and send forth odors of the most fragrant and invigorating character. The air and soil furnish nutriment for these plants, and they digest and assimilate these nutritious products in their crude yet phenomenal and regular manner. Has the plant a circulatory apparatus? Yes. Have you not noticed that it contains little *channels* filled with *fluid?* This is its *blood* or nourishing product. Look again at the leaves. Do you not see peculiarly arranged structures? In the *leaves,* or foliage, the plant abstracts *gases* from the air which helps materially to nourish and support its life; this is the way vegetables *respire* or *breathe.* The plant is self-preserving through its power of utilizing the air and soil. So far and no further, says plant life. My powers reach only so far; man's surpass and reach higher.

Feeling? Yes, but not in plants, generally speaking. Man, or animals, possess more than these ordinary nutritive and respirative functions. They *feel* the existence of something about them *external* to *their little* world. Their *kind* are maintained by the vegetable power, while their feelings, actions and power of thought are strictly animal in character and origin.

In the simple animal like the fresh-water polyp or hydra, we find no special organs for special purposes, but all the parts are similarly endowed. Cut it into many pieces, and each segment acts like the first compact whole, and each

part may, under conditions favorable, develop into a full grown hydra.

In man we become more and more complex; specialized organs, muscles, glands, cells, *nerves.* The last named, *nerves,* being the highest type of development, we take the nervous system, brain and spinal cord as the modifier and controller of all other structures in the body. This system governs the whole body.

Nervous System. This is the "commander-in-chief of the organs" and structures of the whole body. It communicates with every part of the body, and this is accomplished b white, strong cords, or nerve fibres. These form an outline of the whole body, regardless of the other structures, so that if all other tissues of the body were destroyed, this system of nerves would outline the body shape. The *division* of this system is into *Central* and *Peripheral.*

The *Central* system is known as the brain and the spinal cord; gray matter is found on the outer surface of the brain and interior of the cord.

The *Peripheral* system is composed of the nerve cords, fibres and bulbs; they end and begin at distances from the central system.

The Central and Peripheral systems communicate through the spinal nerves, which are outshoots of the spinal cord, passing through the intervertebral foramina. These names are given only for convenience in study, there being no real cut and outlined division. The skull and spinal column protects these two most delicately formed structures, the brain and spinal cord.

The *structure* of the nervous system is somewhat soft, pulpy, semi-fluid in infancy, which slowly but surely hardens as the body develops. Some remain soft, others harden. The degree of exposure controls nature's handiwork. When we look at the tissues with a microscope we learn that they are composed of *two kinds* of distinct elements.

The *white* and the *gray* matter or substance. The white substance is composed of filaments about 1-6000 of an inch in diameter, delicate cylinders, forming the nerve fibres. The

white fibres convey impulses to and from the nervous centers.

FIG. 28.—Diagram illustrating the general arrangement of the nervous system.
a, Cerebrum. *b,* Cerebellum. *c,* Medulla oblongata and pons. *d,* Spinal nerves and branches from the spinal cord.

The *gray* matter is composed of cells, grayish-red in color, variable sizes, generally possessed of one or more

branches, which branches are continuous with the nerve fibres.

It may be said that every cell in our body is a nerve ending.

The only difference between white and gray matter is, the white contains less cells and more fibres than the gray. These cells are so delicate that if once destroyed they cannot reproduce themselves. They do not produce cells of their kind.

FIG. 29.—Nerve cell. All of the processes are protoplasmic except that marked *a*, which is the axis-cylinder process; *b* indicates a clump of pigment granules. (Gerlach).

Cells (from *neuron,* a cord) are made of gray and white matter; they receive record, transmit, and may originate new ideas. They are the dominant powers of the body.

Gray matter is a combination of grayish cells, mixed with a few fibres. These differ as to their neighbors, no one being exactly like another, but they must be connected with other parts. Hence, these *cells* or *neurons* must also have *projections* called poles. Therefore, we necessarily have Bipolar or Multipolar cells. Unipolar cells are impossible. A cell must be connected with *two* things, *another cell* and a *fibre.*

The *cell body* contains near its center a *nucleus* and within it a *nucleolus.* It also has *arms,* (which are filled with protoplasm). These arms branch, and these branches, later, live off other branches, which are called *dendrons.* And still another longer and larger arm, which has an axis cylinder, is found running from the cell, and this is the *fibre* of the cell.

The fibre has an individual and definite composition as shown in the figure above. This structure is different in the embryo and the adult. We find the adult *nerve fibre* composed of an *axis cylinder,* the white *substance* of *Schwann,* the *sheath of schlem,* and the *nodes* of Ranvier.

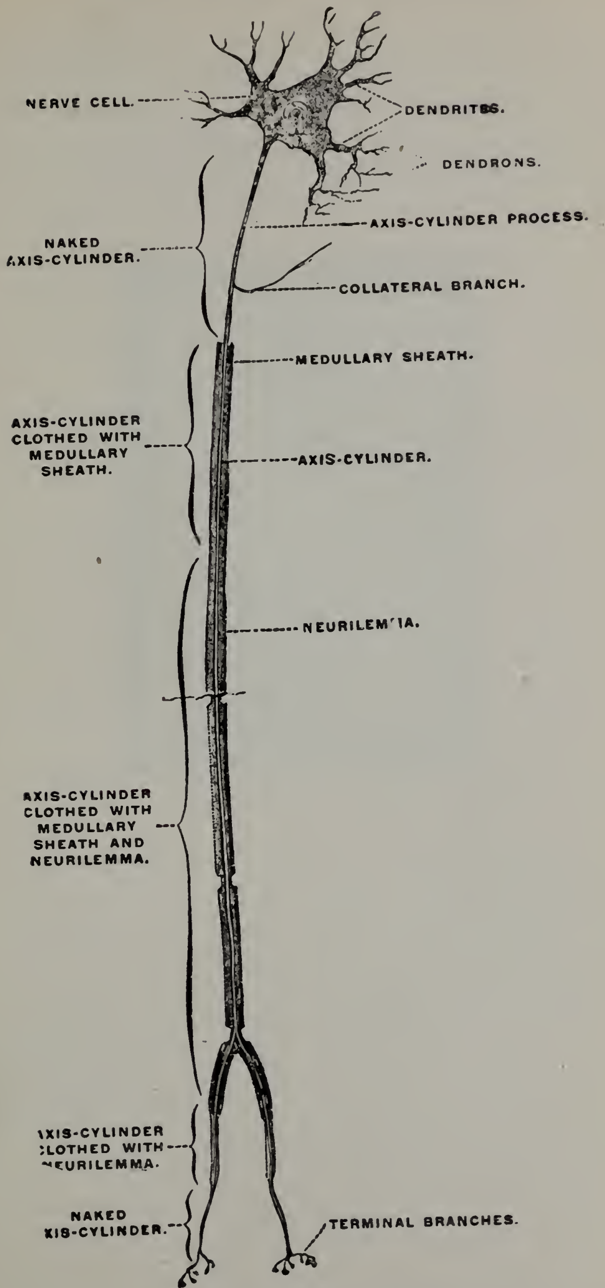


FIG. 30.—A neuron. (Stohr.)

The *axis cylinder* is the important or conducting portion of the nerve, and it is made of many small bundles or fibrillae which are transparent. They are proteid and are surrounded by thin membrane called neuroglia. Some later experimenter says that this is semi-fluid and jelly-like in structure, and conducts only when electricity charges them sufficiently, then

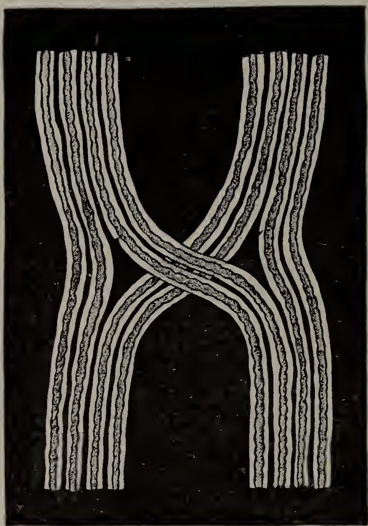


FIG. 31.—Connection between the bundles in a nerve. (Dalton.)

they conduct an impulse one way or the other. This explains why certain chemical substances have the power of stimulating or quieting their activity. It means a complete revolution of nervous theories and physiological experiments, as well as anatomical structure.

This may also explain why *whisky* counteracts the deadly effects of *snake poison*. It is known that snake poison tends to *coagulate* the nerve substance, while the whisky, if given early, will prevent this *coagulation,* and thus prevent death by keeping the nerves in a colloidal condition.

Heat acts as a soothing balm for the same reason. It keeps the coagulation tendency inert.

Anaesthetics generally have the effect of dissolving fat, and so they also keep the nerve particles in a state of solu-

tion, consequently they quiet and make drowsy the nerve substance. This is wonderful, if perfectly true.

The *white substance of Schwann* is supposed to be the *insulating* substance, principally composed of *phosphorized oil* and proteid. It gives the white color to the nerve tissue. It does not receive or conduct, but it merely covers the nerve and may *nourish* it. A nerve can act without its aid, yet by pressure the nerve loses its power. The substance becomes white-cloudy and is absorbed away. Then the nerve loses its function, and may permanently become useless.

The *Sheath of Schlem* is almost imperceptible, it is so thin. We find it surrounding the white substance of Schwann and all along its course we notice *nuclei* of the nerve fiber, scattered at irregular spaces. These *nuclei* may have a great deal to do with nerve regeneration. The white substance of schwan does not continue unbroken, but at certain *points* is *broken.*

These, then, peculiar breaks in the white substance are the *nodes of Ranvier.* These *nodes* may have something to do with nerve nourishment. It is here at these breaks that we find the *axis* and *sheaths of schlem* continuous, but the white substance of Schwann ends abruptly, then begins again. The *nerves* always *branch* at the *nodes.*

Nerves (from *neuron,* a cord) are, we find, long, white, shiny cords connecting the nervous centers together, and they place these centers in direct and indirect communication with each other and also in communication with all the different parts of the body. The *brain* and *spinal cord* preside more especially over the *animal functions* of the body; the *sympathetic* system over the *vegetable functions.*

Dendrons do not unite with *each other,* but after *branching* several times, they *end in* a *brush* which surrounds another brush, but does not *touch it.* Therefore, we conclude that *impulses* must pass by *contiguity* and not by *continuity.* These dendrons of cells never stop growing, but *increase* in proportion to our intellectual exercise and study. *Impulses* travel *only* through the dendrons. Cut the dendrons and no impulses pass. Cut an *axis cylinder* and no impulse can pass

away from the cell. Hence the dendrons are *cellulipetal,* and the *axis cylinder* is *cellulifugal* fibres. Dendrons have no collateral branches; the axis cylinders have, and these collaterals have branches and all these collaterals end in the brushes which we find among the dendrons. Thus, we see how *impulses* may be sent through the *axis cylinder* to *dendron,* and hence to the cells.

These cells and arms are filled with protoplasm, except one arm which is the *central axis,* or nerve fibre. Trace this fibre down a little and you come to the white substance of Schwann. In these cells we find *tracings* or marks through the protoplasm of the arms, some better marked than others; they are called *roads* travelled by ideas and thoughts. Thus you can tell which have been the most used for travel. No one, however, can tell whether they are travelled by good or bad impulses. Sometimes we find fibres coming from a network of arms; therefore, a cell is not *always directly* joined to a fibre.

Nerve Fibres connect with the central system in two ways, *directly,* by the *axis cylinder; indirectly,* by fibres from the *network* of arms just mentioned. These nerves are *alkaline* while at rest; they are *acid* during action. Some say that the impulses in these nerves travel slower when the body is least charged with electricity. An electrical current will, when applied, not run all the way down the nerve. It will go in at one point and out at another slightly lower. *Conductility* is increased by heat, health, bile, light, sound, etc.; it is *decreased* by cold, opium; disease may either increase or decrease its conductility.

There are *two* kinds of nerve fibres, *motor* and *sensory.* One is for motion; the other for sensation.

The *motor root* comes from the *anterior horn* of gray matter in the spinal cord; the *sensory root* from the *posterior horn.* So from this fact we learn that a man may be injured in his leg nerves and *retain motion,* but *lose sensation.* These fibres are alike in character, and only by stimulating or experimenting can we tell the difference between a motor or a sensory nerve.

A nerve may be temporarily compressed and injured; it thus loses its function. We call this temporary *paralysis*. A man may so compress an arm nerve by hanging it over the back of a chair and falling into sleep; on awakening his arm is partially useless for a while. The first return of sensation *begins* in the fingers by tingling. The brain thus intercepts all injuries to nerves. All the spinal nerves and a few from the brain are concerned with *sensation* and *motion*. The other cranial nerves are either specially motor, sensory or exclusively special in their impressions, such as sight, smell, hearing, etc. These sensations of motion, or otherwise, travel along the nerves at the rate of about 100 to 200 ft. per second.

Nerves convey in both directions. Cut a rat's tail off, after first sewing its *tip* to a wound on the back. When the tail is firmly attached to the back, heat its now free extremity (which was its root) and the rat moves, showing that the sensation of heat travels *backward* as well as forward.

Nerves are not elastic. They are always longer than the limb in which they run; they fold up when the limb is flexed. They are very tough and strong; a lower extremity may be lifted by the sciatic nerve cord. In fact, nerve stretching is recommended by some for old cases of inflammation as a cure remedy.

This nerve-stretching only breaks up the nerve-adhesions and injures the sensibility of the cord, thus we *feel less pain,* but we also have *less activity* of the *limb*. Sensory fibres recuperate more rapidly than motor.

Extracting water from nerves cause them to be self-stimulated abnormally. Hence, in long cases of diarrhea or cholera we have the most fearful and painful cramps. Sugar is one of the most potent stimulants of nerve tissue. When electricity is applied to a nerve it takes 15-10,000 of a second to act; and a constant current does not stimulate a nerve to contract; it only stimulates when first applied. The *positive pole* is that where the current of electricity *enters;* the negative *pole,* where it makes its *exit*. The negative pole causes contraction; the positive pole, only when taken away.

Afferent nerve fibres carry impulses *to* the center; *efferent* nerve fibres *away* from the center. The *afferent* are *sensory* fibres; the *efferent, motor* fibres. A motor fibre must supply every muscular fibre. *Secretory* fibres also come from the center and cause the glands to give up their contents; and the vaso motors we know act on the blood vessels, regulating their size.

Trophic fibres are those which influence the chemical changes or metabolism of the tissues.

They are the nerves of irritation. Nerves themselves must have trophic fibres to supply their wants. Cut a nerve across and note the fibrest below the cut, degenerating. Those above do not. Also, if these cut ends are brought together again they will regenerate.

Walerian Law of nutrition is: Cut a nerve above the posterior ganglion and the part with the ganglion attached will not be affected, but the part near the cord will degenerate. Cut a nervve from its trophic center and it degenerates peripherally. Cutting above or below the ganglion on the posterior spinal nerves will show these degenerations.

The nerve cells of the anterior horn act as nourishing centers to the motor nerves. Those special ganglions on the posterior spinal nerves have cells which act as nourishing centers to these posterior nerves. Thus, if the nerve degenerates, the same results are found in the muscle supplied by that nerve. It also degenerates.

Voluntary impulses come directly from our wills; involuntary, from the ganglion cells found in the cord and outside and upon the spinal cord posterior nerves. Or, we may have involuntary influences coming from the brain, too; as in the action of the heart-muscles and their nerves.

Reflex Action. There are animals which *act* after removing certain parts of the brain, such as the alligator, frog, terrapin, etc. They respond to stimuli, showing that they can move and *feel* a knowledge of that which hurts them, yet, have no brains left, to speak of. We can even get the same results if the whole brain is removed. This is *reflex* motion.

We eat, walk, swim, play on the piano and do most all our minor actions by reflex motions. The brain deals with major problems, not these minor ones. Tight-rope walkers, pianists, skilled artisans, all, do their many feats by reflexes. Does the body mean to perform all those queer actions? No. The body is a bundle of reflexes, according to Dr. Miles. When it is born its nervous system is unfinished, incomplete. The white matter of the cord is deficient. There is no road for the impulse to travel. Why does it perform so many and varied motions? It is made to do so; so-born.

If we care to walk we only set the reflexes to work. We don't watch every muscle, or dictate to each finger in playing on the piano. In the early period of learning to walk and play, we do use the brain at times, but later we leave these motions to the reflexes. Punch at a child and notice how it flexes its arms and legs to protect its body. All reflex. These are great saving devices by nature. She protects our brains from trivial fatigue and minor actions.

Reflex Inhibitors are shown when we bite our lips and restrain from moving a foot when it is tickled. *Savages* show their passions and pleasures to an extreme degree. *We* have learned to control ours. A man cannot sneeze if he thinks intensely of it. Erection of the penis is simply reflex, and if you observe it, it will be prevented. Hence, many men think themselves impotent when they are not. We should control our feelings, no matter how strong.

The spinal cord is the great center for the reflexes. It stops many thoughts, or reflects them, and thus *saves the brain.* Example is seen in a decapitated fowl; it jumps violently about, without its brain. A centipede cut in half will run about and seem to try and overrun or turn obstacles met with in its path. A frog will stand up after its head has been cut off. If pushed over, it regains its feet; it may even jump. We cannot keep our equilibrium unless we *feel* the ground on which we walk. Strychnia increases reflexes; bromides decrease them. Deep reflexes of diseases increase, while the skin abates. In hemiplegia, the skin of the paralyzed side will not act. Strike sharply the thigh and the testicle draws up; possibly for protection.

The skin and the tendons offer special reflexes. The latter is shown in ankle-klonas, knee-jerk and jaw-jerk, etc. These may not be true reflexes, however.

A Reflex Act is caused by an *impression* being carried by an *axis cylinder* to a *sensory nerve cell,* then it *transmits* it to *another cell,* through its dendron; this *second cell* sends down the modified *impression* to the *muscle* or *gland* to be acted upon. If a *nerve cell* is repeatedly stimulated it becomes *exhausted* and will not act; fibres never become exhausted; they are passive agents only.

The Spinal Cord reflexes protect the body. If a hot coin or wax falls on the hand, it is quickly snatched away, even before the brain receives the impression. "Tone" is reflex in character. Good, bad or irregular news may effect the reflex, and therefore tone of certain muscles; or, in disease, like St. Vitus' dance; or convulsive grief. The reflexes are sleepless, ever-acting, protecting, nourishing, excreting, substituting, overseeing the parts to relieve the brain-action and save brain force and energy.

- Nerve-fibres ....
  - Afferent .... Sensory, Reflex, Excito-Motor and Inhibitory.
  - Efferent .... Motor, Vaso-Motor, Secretory, Trophic and Inhibitory.

SPINAL CORD.

In the skull we find the *brain*, and in the neural canal of the spinal column, the *spinal cord* is found; the two joining at the foramen magnum of the occipital bone, and forming the great cerebro-spinal nerve-center.

This center is symmetrical, bilaterally throughout, except at intervals we find slight differences on the surfaces of parts of the brain, in the higher races or casts of men. This brain and cord are both extremely soft and easily crushed; their connective tissue, running their entire course, being delicate and of the retiform variety. Hence, they are protected by complete bony circles; the skull for the brain; the canal in the spinal column for the spinal cord. Besides these hard tissues we find certain *membranes* inside the bones, *three* in number, also covering and protecting the organs named.

Dura Mater (tough mother) is a tough and very strong white fibrous and elastic connective tissue, covering the brain and cord loosely, and not attached to the bony boundary, except in the skull, but is surrounded by fibrous tissue and vessels which serve to pad the *canal, especially* to prevent shock.

Space is now reached, which is between the dura mater and the next membrane; this space is called the sub-dural space. It has a small quantity of fluid (cerebro-spinal) between its two lays; one layer lines the inner parts of the dura mater; the other lines the outer surface of the next layer, called pia mater, and between the two we find the fluid. These layers are made of flat, closely-fitting cells, and the *fluid* between these layers is supposed to dissipate *shock*. The two layers form the *arachnoid* (spider web), which is the middle membrane.

Pia Mater (tender mother) is the third and internal layer of membranes. It dips down in between the brain or spinal grooves, fissures, etc. The other two run over these fissures and sulci, and do not dip down. This layer is composed also of white fibrous and elastic tissue, but less closely interwoven than the dura mater. This membrane has many blood vessels, which break up into numerous branches.

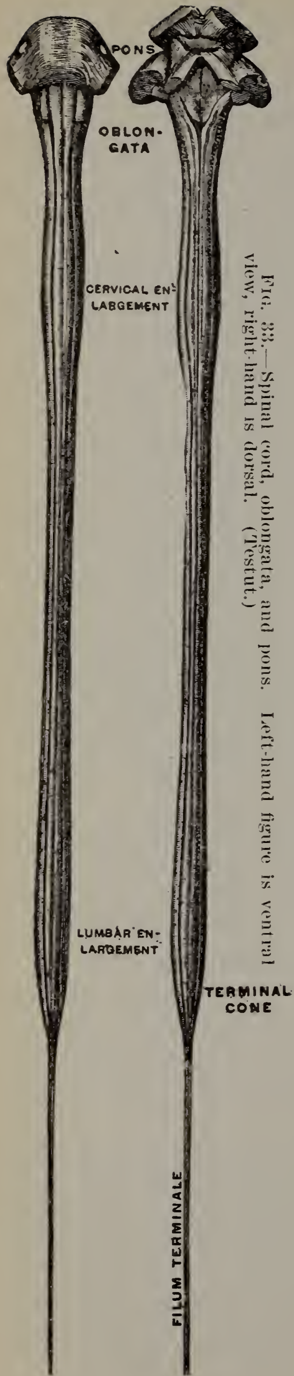


FIG. 33.—Spinal cord, oblongata, and pons. Left-hand figure is ventral view, right-hand is dorsal. (Testut.)

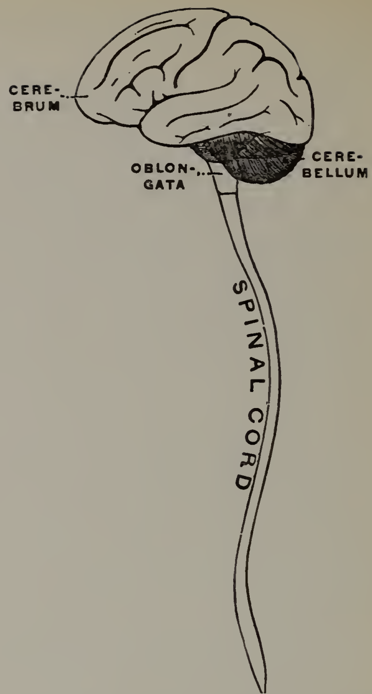


FIG. 32.—Semidiagrammatic view of the cerebro-spinal axis, left side. (Testut.)

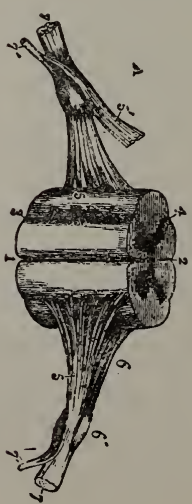


FIG. 34.
Cross section of spinal cord, showing arrangement of columns.

The Spinal Cord is almost cylindrical in form; it is, however, slightly wider from side to side than antero-posteriorly. It tapers off to a *filum terminale,* opposite the second lumbar vertebra, surrounded by numerous loose nerve fibres, which, collectively, are called the *cauda equina* (horse tail). The spinal cord begins opposite the transverse ligament in the first vertebra (atlas). It is about three-quarters of an inch in diameter, weighs 1½ to 2 ounces, and is about 17 to 18 inches long. The enlargements are found in the cervical and lumbar regions, where the large nerves for the arms and legs are, respectively, given off.

The cord is composed of gray and white matter, the *gray within* and the *white without.* This is the reverse of the arrangement in the brain; the white being internal and the gray external in that organ.

In the middle line on both the ventral and the dorsal sides of the cord is a groove. On a cross section these grooves show the fissures into which they lead, and they help, seemingly, to divide the cord into lateral halves. The *anterior fissure* is wider and more shallow than the *posterior.* At the bottom we find the gray commissures.

On transverse section we notice that the gray matter in the center of the cord consists of two lateral masses arranged somewhat like a letter H. Each half is crescent-shaped, and are turned with their convexities toward each other, and they are connected or united back to back by a middle line or connection called the *gray commissure.* In the center of this commissure we find a small canal called *neural* canal; it is lined with ciliated epithelium, and is called the *sixth ventricle* The gray matter is more abundant in the cervical and lumbar regions of the cord. Around this central canal and the extremities of the posterior horn we find the gelatenous substance of Rolando. The gray matter crescents *end* in two anterior horns (cornua) and two posterior horns (cornua). The *anterior cornua* are thicker and larger than the *posterior.*

The *gray matter* is composed of nerve cells and their processes and neuroglia, chief among these being the neuroglia.

We find the cells in the anterior and posterior horns. Those in the anterior are very large, being the largest found in the body; they have an axis cylinder, which helps to form the anterior or motor root of the spinal nerve. The cells in the posterior horn are smaller and fewer in number than those found in the anterior.

There are other peculiar cells grouped together in the median line of the cervical region, near the anterior column. These may be termed the median cells. In the dorsal and lumbar regions there are smaller cells, especially grouped externally to the gray matter; these are called the *lateral horns.*

The *White Matter* of the cord is not of uniform character, but on close examination we find the nerve roots serving to outline the location of the anterior, posterior and lateral column. We have no way of distinguishing the parts of the various columns, however.

Close inspection shows us an inner median portion next to the posterior fissure or septum, and it is called the posterior median column, or the column of *Goll.* Immediately external to this is the column posterior external or column of *Burdach.* Further than this we seem not to be able to go, for we cannot separate or distinguish one part from another with a knife, as far as the nature of the nerve is concerned. We now, however, that the column has fibres or tracts, and that these tracts or columns differ in their connections at their respective ends; that they act differently; perform different functions under certain circumstances, and we fail to separate them because of the fibres being very much mixed with others of a different nature and origin.

From these facts we deduct certain regular functions from each major column or tract. To further demonstrate these facts we find embryologically that some of these nerves' axis cylinders do not put on their medullae *at the same time.* Some occur early; others late. This materially helps to exclude or include certain parts in experiments. In the degenative process of nerve tissue we also have important clues to physiological functions of these tracts and columns of the cord.

These facts have enabled anatomists and physiologists to divide the spinal cord into special columns or tracts suitable for accurate tracings of impulses going to and coming from the brain and spinal cells.

We have two kinds of tracts, *descending* and *ascending*. The principal *descending tracts* are grouped together and the *ascending* tracts, too, are so classed.

The cord is dentated anteriorly by the deep groove or fissure; posteriorly by a narrow fissure or septum or raphae, allowing communication from one side to the other; indeed, disease crosses from side to side posteriorly, but rarely is this true of the anterior aspect.

The columns between the anterior fissure and the anterior horns of the gray matter of the cord are the *anterior columns.* These columns are divided into two tracts; those next to the anterior fissure are the anterior or direct pyramidal tracts (the uncrossed fibres from above) for motor impulses; this is, then, a descending tract. The second are the ground columns.

From the anterior roots of the anterior horn clear around to the posterior roots of the posterior horns, are the *lateral columns,* or crossed pyramidal tracts.

Behind that limit to the posterior fissure or raphae are the *posterior column; Goll* next to the fissure, and *Burdach* externally situated but not entirely separated from Goll.

The *crossed pyramidal tracts* are anterior to the posterior horns, and nearing the *edge* of the cord. *Outside* of these are the direct cerebellar tracts and *Gower's tracts* in front along the margin of the cord.

Between the anterior columns we have a commissure of *white* matter; behind the central or neural canal, the gray matter is called the posterior *gray commissure.* On opening the *posterior* fissure or raphae, we come to *gray* matter. The spinal accessory nerve comes off from the lateral horns or tracts of the cord. Hence they have been called *motor cells.*

There are certain fibres which cross or decussate over to the other side, as the pyramids are about to pass to the cord. This explains why a blow on one side of the head causes paralysis on the opposite side of the body.

The direct cerebellar tract is the most conspicuous ascending tract. It begins in the lumbar region, enlarges as it passes through the dorsal and increases still more as it enters the cervical region and pierces the *restiform bodies* or *peduncles* of the cerebellum; hence the name above.

The *second* important *ascending tracts* are found in the median-posterior column; they end in the bulbs. The *third ascending tract* is *corna-shaped.* Its head is found between the pyramidal and the direct cerebellar tract, and its tail extends in a vertical direction toward the anterior roots. The columns of *Burdach* are also, less important ascending tracts.

The spinal nerves and spinal cord connections are thirty-one in number. They enter in pairs by passing through the intervertebral foramina. Each pair divide into a ventral and dorsal portion, known, respectively, as the anterior and posterior roots of the nerves. These again subdivide into finer branches, which are attached to the sides of the cord opposite to the *anterior* and *posterior horns* of gray matter. On each posterior root we find a *spinal ganglia,* placed just before they join the anterior trunk to make up the common nerve cord or fibre. Immediately after coming in contact (these two, the anterior and posterior roots forming one trunk), these now divide into a small posterior *primary branch* and a larger *anterior primary branch.* The posterior branches supply the muscles of the back and skin, while the anterior branches form a series of spinal nerves, called plexuses, from which the nerves for the *sides* and *ventral* regions of the *neck, trunk* and the *whole* of the *limbs* arise.

There are 8 cervical, 12 dorsal, 5 lumbar, 5 sacral and 1 coccygeal pairs of spinal nerves. The student can refer to anatomy for the distribution of these plexuses of spinal nerves.

The continuation of the axis cylinder of the cells in the anterior horn communicate and mix with the fibres of anterior spinal nerves. They are large and are supposedly *motor* in character. Some of the fibres of the anterior cord or horn are not from the cells and axis cylinders of these cells, but they run back to the posterior horn and some even

to the lateral columns, and more complicated still, some may be traced to the bottom of the anterior fissure and crossing over to the other side appear to ascend to the anterior horn of the opposite side.

The posterior roots enter the cord in a more compact bundle than the anterior. They have two distinct bundles, however, which take different directions after entering the cord. The *large bundle* being coarser in structure, pass obliquely into the external posterior column, sometimes called the posterior root *zone*. Most of these fibres run straight upward, but some change their course and pass into the posterior horn and others may go through to the anterior horn.

The *small bundle* are mixed with coarse and fine fibres. The *coarse fibres* run *directly* into the *substance of Rolando* and then to the gray matter of the cord. A few fibres run to the anterior horn; others longitudinally upward. The *fine fibres* ascend directly and give off fibres to the gray matter as they pass up, and ultimately seem to *end* in the gray matter. Others form the median posterior tracts.

The Peduncles of the brain communicate and are continuous with the tracts of the spinal cord. It will be mentioned later as being an important factor in holding the hemispheres in relation with the cerebellum and Pons. To trace an impulse we have to pass through part of the peduncle.

It is divided into two portions by the *Locus Niger*. The grayish white matter is called the *Tegmentum*. The *white matter* is called *Crusta*. This crusta is divided into the middle 2-4, which tract allows motor impulses to pass. The external ¼ on each side of the motor area is for *sensory* impulses. And immediately external to the fibres of sensation we find a few fibres which run to the Pons and stop.

Trace an *Impulse* from the brain cortex to the muscle on or near the periphery. An ordinary impression will pass from the *cells* of the *cortex* of the *brain,* through the *corona radiata, internal capsule,* middle 2-4 of *cruri cerebri* (crusta), *Pons* (facicali teretes), and *anterior pyramids* down to the *cross pyramidal* tracts; then fibres pass from the *lateral* tract, to the *anterior horn* of the cord, and *nerve pass out* from there to the *muscle*. Then it *acts*.

Return impulses travel through the *posterior* pyramids instead of the anterior pyramids. These are found to pass through Gower's column.

Gower thinks that the sensation of *pain* travels up his *column*, which is found at the anterior part of the lateral columns. Others think it passes in the gray matter.

The columns of *Goll* and *Burdach* probably cross in the posterior gray commissure.

The *blood supply* of the *cord* mainly comes from *spinal* branches, from the intercostals, and from spinal branches, given off by the *vertebral*, which are called *anterior* and *posterior* spinal arteries; these are given off in the cranium and run down into the neural canal to supply the membranes and cord. In the neck we also find the *vertebral* giving off *lateral spinal* arteries which enter the spinal canal *through* the *intervertebral foramina.*

THE BRAIN, OR ENCEPHALON (IN THE HEAD).

The Brain is the great nervous mass, which occupies the main cavity of the cranium. The *cord* is a prolongation of the brain, and is called myelon (marrow) or spinal cord. The two, *brain* and *spinal cord* form the so-called *cerebro-spinal-axis.* "We notice this *axis* in the embryo as a dorsal groove. Its edges grow up at the sides, curving inward, meet, and fuse togethr. The groove or gutter thus changes into a *tube. One end* of the tube enlarges into a *sac,* and this develops into the brain. The remaining portion of the tube becomes the spinal cord, thus, the cavity or ventricle (4th) is continuous with that of the spinal cord. From this beginning the brain amazingly develops, becomes complicated and changes; but three embryonic things remain as in the simplest form: (1) a cavity wall of nervous tissue; (2) a lining of epithelium, and (3) a membranous-vascular covering."

The *shape* of the *brain,* nor *appearance* gives us any idea of its functions, as we find is the case in many other organs. Again, packed away in this small space, we have organs with the most varied functions, and their boundaries, too, imperfectly divided. It consists of two kinds of substances,

gray and *white* matter. Wherever you cut into the brain you find a mixture of these substances, or one of them alone. *Gray* matter is made up principally of cells, although we find on closer inspection a *mixture* of *first gray* then *white*, till we come to the white matter deep down under the *cap* of gray matter. White matter is made up of *fibres*. An excess of gray matter makes the cortex look gray, yet we find layers of white there, too.

Gray matter receives, records, may originate and transmits impressions.

White matter is merely the connecting links between different parts of gray matter. It *conducts ideas*. If *white matter* is injured we have loss of conduction. If *gray matter* is injured we have loss of *function* complete.

The brain is a solid avoidal; corvex above; concave and irregular beneath; narrower in front than behind, and convex or rounded laterally. It weighs about 48 or 50 ounces in the male on an average; in women it averages about 44 ounces. This weight as compared to the weight of the body differs in different periods of life in the same person. In idiots, the weight ranges from 27 to 8.5 ounces. The average sane brain is heavier than that of an insane person. Tall men ,generally, have larger brains than small men. Usually in human beings the size of the brain is proportional to the mental development. There are exceptions, of course. Sometimes we find a stupid man with a larger brain than a clever man. Or, a peach-shaped brain, small and irregular, may be the seat of the most wonderful thought and force. There are on record a few very heavy brains from eminent men:

Cuvier, 64.5 oz.	Lord Campbell, 53.5 oz.
Daniel Webster, 63 oz.	Agassiz, 63.4 oz.
Abercrombie, 63 oz.	Dr. Morgan, 52.7 oz.

The old mulatto who sat and spent his time whittling a stick in Kentucky had a brain weighing 60 ounces. Man's brain is heavier than any other animal's except that of the elephant and whale.

The brain is situated in the cranial cavity and is the principal part of the nervous system. We divide it into four

portions, the *cerebrum,* the *cerebellum,* the *pons varoli* and the *medulla oblongata.*

The *membranes* of the *brain* are three in number. They are called *meninges,* or membranes.

The *Dura Mater* (tough mother) is the real protection of the brain next in importance to the cranial bones. It is tough, strong and attached to the sides and vault of the skull box. The membrane leaves certain spaces between its attached extremities for the protection of the veins of the skull and brain. These are called *sinuses,* and are occupied by veins. The processes of the membranes which form them are called falx or sickle of the brain. As they become at-

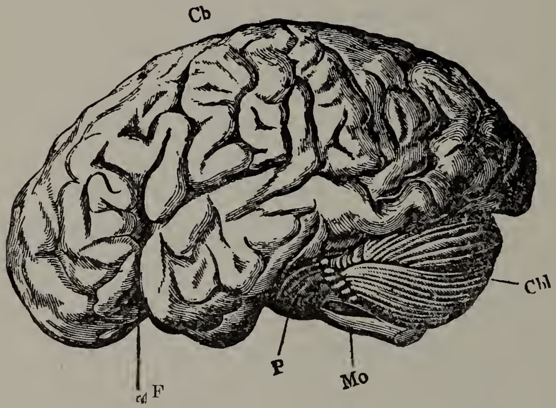


FIG. 35.—The brain from the left side. *Cb,* the cerebral hemispheres forming the main bulk of the fore-brain ; *Cbl,* the cerebellum ; *Mo,* the medulla oblongata ; *P,* the pons Varolii ; *F,* the fissure of Sylvius.

tached to the skull internally they separate like a wedge, with its base toward the bone and its apex in the converged two layers of the membrane. Cut out the bone to a large diameter and the Dura Mater will still protect the brain by its inelastic strong fibrous structure.

The infant's skull bones are incompletely developed; therefore, we have left one large opening in the anterior and one smaller in the posterior aspect of the cranium. What protects the brain at these exposed areas? The Dura Mater.

This Dura Mater reaches over the lateral sinuses to the petrous border of the temporal bones and clinoid processes of the sphenoid and forms a strong blood fibrous *tent* or *ten-*

torium cerebelli. This sheet of tissue separates the occipital lobe of the cerebrum from the *little brain, cerebellum.* It prevents the weight of the cerebrum from resting upon the cerebellum, which is easily influenced by pressure.

The arachnoid (spider's web) is the next or middle layer. We first reach a space. It is the sub-dural space, filled with fluid, with which shock is disseminated or prevented or dissipated. It is made of epithelium and lines the dura mater, and the next or third layer, the pia mater. The fluid is called *cerebro-spinal fluid.*

Pia Mater (tender mother) is the most internal layer of the membranes. It dips down into the fissures, sulci, etc., of the brain. The other two pass over these. It is composed of white fibrous and elastic tissue, but not as firm or strong as the dura mater. There are numerous blood vessels and branches in this membrane.

The *cerebrum* forms the largest part of the brain, and will also occupy the principal portion of the cranial cavity anteriorly and centrally and rests upon the tentorium cerebelli posteriorly. In its middle is a somewhat contracted portion, which we call the crura cerebri. These crura pass down through the pons to the spinal cord, and another part of these crura (peduncles) is called the crura cerebelli, which are so named because they pass into the cerebelium.

The *cerebellum* (little-brain or hind-brain) is found underneath the tentorium cerebelli, and rest upon the inferior cerebellar fossae of the occipital bone. It is in contact with the rest of the brain through connecting bridges or bands; we call these crura; two cross to the cerebrum; two to the medulla oblongata and two enter the pons.

The *Pons* rests upon the basilar portion of the occipital bone, and the dorsum Ephippii of the sphenoid bone. It is the bond of union of all the brain. It receives the crura of the cerebrum above, laterally from the cerebrum, and also those from the medulla below.

The *Medulla Oblongata* begins at the lower border of the pons and extends to the transverse ligament of the atlas. It is below the cerebellum, and rests upon the basilar groove of the occipital bone.

The Cerebrum is the largest part of the brain. The brain is, then, far larger than the spinal cord and much more complex in structure. In *birds,* the canary and singing birds generally, we find proportionally more nervous tissue throughout their bodies, but the brain is small. Man alone excels in *cerebral matter,* which means high-order areas—thought, memory, intellect. The owl has a large head, but a small space for the brain. A healthy man's brain is full of energy and flushed with nature's best and strongest thoughts when he awakens. If he eats breakfast, that, too, should reinforce the high spirited feeling. As the day wears on, "tired nature," claims a relaxation and *sleep* gradually claims her time for *repair* and building up tissue anew, for brain tissue, of all tissues of the body, needs and requires *repair.*

The cerebrum, or proper brain, is the seat of the mind. It occupies the loftiest position of the body; so, therefore, does it fulfill the highest and noblest uses. It is the commander-in-chief of all the organs and tissues of the body. Our five or six senses, of sight, smell, etc., are its messengers, which bring it information from the world without. The motor organs (muscles) execute its commands. What part of the cerebrum does this? The cortex, or gray matter—the highest element of power.

The cerebrum is ovoidal in outline, is narrower in front than posteriorly. It is convex from before, backward and laterally, as well as transversely. The base is slightly irregular, but flattened. It is divided into lateral halves, or two huge convoluted masses, separated from one another by a deep median fissure, and we know these masses as *hemispheres*—cerebral hemispheres. Beneath each cerebral hemisphere is an *olfactory lobe* or *bulb,* small in man (gives us the sense of smell), but in some *fishes* it is much larger than their cerebral hemispheres. The *great longitudinal* or *median fissure,* which dips down to the base of the brain in front and behind, is interrupted in the central portion by a broad transverse band of white matter which connects the two hemispheres. This *white tissue* is called the *corpus callosum.* This fissure lodges the falx cerebri (spur of cerebri) and

shows us the manner of the original or primary development of the brain into two segments, or lateral halves.

THE HEMISPHERES.

It is wonderful, yet true, that these *hemispheres*, frought with so much important matter, are, singularly enough, very insensitive. A large piece of brain tissue has been removed, on account of an accident, and the patient lived, without causing very much serious damage to the intellect. A most

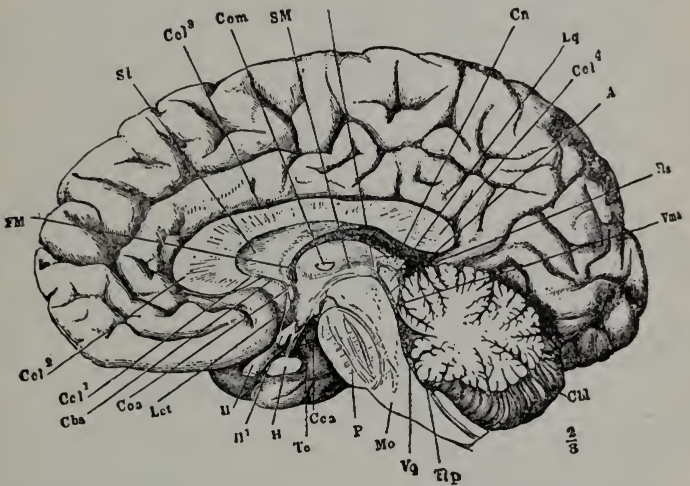


FIG. 36.—The right half of the brain as seen on its median side after a section made through the organ in the middle line. *Vq*, fourth ventricle; *Mo*, medulla oblongata; *P*, pons Varolii; *II*, optic nerve; *H*, pituitary body; *Coa*, anterior commissure; *FM*, foramen of Monro leading from the third ventricle, in the cavity of which the lower end of the line *SM* lies, to the right lateral ventricle: *Com*, soft commissure, running from side of the third ventricle, divided; *Cop*, posterior commissure; *Lq*, *corpora quadrigemina*; *A*, aqueduct of Sylvius or *iter a terio ad quartum ventriculum*; *Cbl*, cerebellum; *Ccl*-1, *Ccl*-2, corpus collosum; *Sl*, septum lucidum; *II*-1, the divided optic commissure.

noted case was once recorded of a man who lived and regained his health, after having an explosion of powder drive through his head an iron rod 3 ft. 7 in. long and 1¼ in. in diameter and weighing 13 pounds. It passed from below his ear outward and upward, taking brain, membrane and bone fragments with it. His greatest loss was the sight of one eye. A disease may injure a large part of the brain without injuring the faculties of the mind.

A *hemisphere* has an outer convex surface, and an inner flattened surface. Its under surface or base is irregular; it rests upon the *anterior* and *middle fossae* of the base of the skull, and behind it rests upon the *tentorium cerebelli.*

We notice on the outer convex surface of the hemisphere numerous *eminences,* which are called *convolutions* or *gyri,* and between these, *depressions,* which are called *fissures* and *sulci.* Covering these numerous eminences and depressions, and also the whole surface of each, including their *sides* and *bottom,* is *gray matter.* This gray matter is called the *cortex* of the brain, or cortical substance. Why is this arrangement of depression and eminences? It is nature economizing space and tissue; but for this arrangement we would require a head as large as a bushel or larger. So this infolding increase the amount of gray matter without utilizing too much space. These convolutions were regarded as indexes to our intellectual powers; if they were *deep* and *numerous,* the individual was supposed to have been a strong man *mentally;* if they were shallow and few in number, the individual was correspondingly stupid. Now, physiologists give very little importance to such reasoning. In fact, most of them hold to the idea that phrenologists are a sham, and a lot of freaks, knowing absolutely nothing about the markings of the exterior of the brain. However, the theory is seemingly plausible from cases cited, and may have some truth in it at times.

These hemispheres are not usually symmetrical on the two sides; the *sulci* depend upon the convolutions as to their length and depth.

The fissures on the outer and inner aspect of the hemispheres divide them into *lobes*

There are *five* important fissures on the outer surface, which separates it into an equal number of lobes.

The greatest of these fissures is the *longitudinal,* which separates the hemispheres from each other.

The *sylvian fissure* begins at the base of the brain at the *anterior perforated space,* and passes outward and forward to the external surface of the hemisphere. This fissure divides into two *limbs.* One, the shorter of the two,

passes up toward the great longitudinal fissure, is called the *perpendicular limb.* The other, longer one, passes somewhat in a horizontal and backward course, and is, therefore, called the *horizontal limb.*

The *fissure* of *Rolando* is found about the middle of the external surface of the hemisphere. It begins at the border of the great longitudinal fissure, one-half inch *behind* the

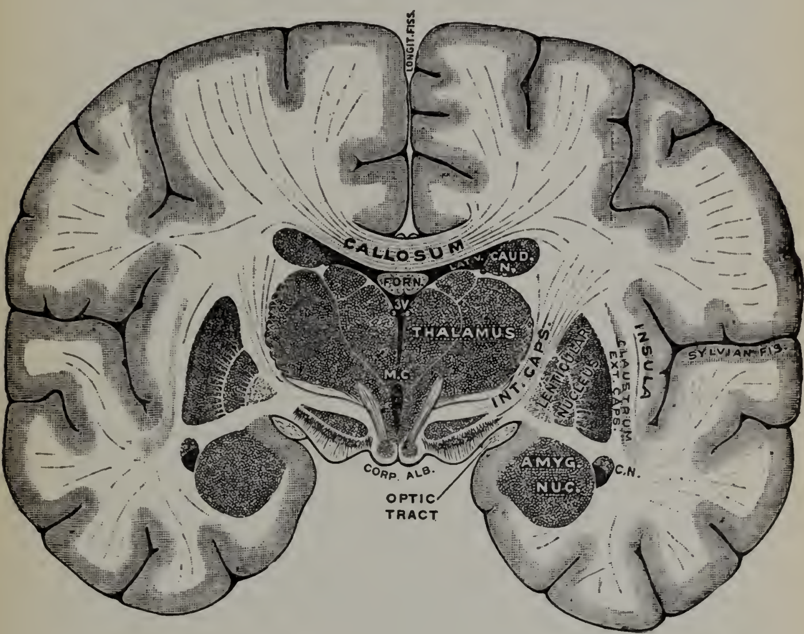


FIG. 36½.—Coronal section of the hemispheres through the middle commissure, M. C. C. N., caudate nucleus in the roof of the middle horn of the right lateral ventricle. (Testut.)

middle point of a line reaching from the globella in front to the external occipital protuberance and runs downward and forward, getting very near to the perpendicular limb of the sylvian fissure. Its angle in this course is about 67° to that of the longitudinal fissure. The *Genu* of this fissure is a knee-like bend made at the junction of the lower third with the upper two-thirds of the fissure. It is in the region of this fissure that we have the motor area located, and especially in *front* of the fissure is this motor area located. The author

has, in experimenting upon groundhogs and rabbits, come to the conclusion that the *book supposition* of this motor area spreading over both the *anterior* and *posterior* parts of the fissure is *incorrect.* It is almost exclusively limited to the *anterior region,* and not to the posterior.

The *parieto-occipital fissure* begins midway between the posterior extremity of the brain and the Rolando fissure. It runs downward and forward and ends in an indistinct line below.

The *transverse fissure* is the space which separates the occipital lobes from the cerebellum. It is occupied by the tentorium cerebelli.

Lobes. There are five principal lobes as a result of these fissure formations. They are the *frontal, temporal, sphenoidal, occipital, parietal,* and the *sixth,* sometimes so classed, the *Island of Reil.*

The *frontal lobe* is in front of the fissure of Rolando and above the fissure of *sylvius* It rests upon the orbital plate of the frontal bone and is called by some the *orbital lobe.* It is further divided into four other convolutions or lobules; the precentral fissure separates the ascending frontal convolution from the rest of the lobe. The remainder of this lobe is subdivided into three smaller ones by two short sulci running from before backward, which are called the superior and inferior sulci. These lobes are known as the 1st, 2d and 3d, or the superior, middle and inferior convolutions. The last named is called Broca's convolutions.

The under surface of the frontal lobe is called the orbital lobe, and it has a deep sulci or groove for the olfactory bulb.

The *parietal lobe* is bounded anteriorly by the fissure of Rolando; posteriorly by the parieto-occipital fissure and inferiorly by the horizontal limb of the fissure of sylvius. There are four well-marked convolutions, more or less separated by smaller fissures in this lobe. Other fissures and convolutions here we deem unimportant.

The *temporo-spenoidal lobe* is bounded anteriorly and above by the fissure of sylvius; behind we find it in relation with the occipital lobe, and is found lodged in the middle

fossa of the skull. It is subdivided into three smaller convolutions.

The *occipital lobe* is the most posterior one of the brain, and is limited above by the parieto-occipital fissure. In front and below we find it connected with the parietal and temporo-sphenoidal transverse fissures, which form three convolutions of minor size and importance.

The *central lobe* or *Island of Reil* is located at the angle of the fissure of sylvius, and at its bottom. It is covered over, overlapped by the overhanging ends of the ascending frontal and the ascending parietal convolutions. This island of Reil is composed of a triangular shaped area of five or six convolutions. The opening into the seat of this lobe is called the *operculum*.

Inner Surface of a Hemisphere. The *Internal* or *Median Surface* of a hemisphere has fewer and less complex convolutions than the external surface. They are, too, more plainly defined. The lobules are scarcer and smaller than those externally.

The fissures in this region are five in number: Calloso-marginal, parietal, occipital, calcarine, collateral and dentate.

The *calloso-marginal* fissure begins below the anterior extremity of the corpus callosum, bends around this body, and continues parallel with it from before backward between the margin of the hemisphere and the corpus callosum, about the middle of the brain; then it ascends to the margin of the hemisphere. It separates the marginal convolution from the gyrus fornicatus.

The *parieto-occipital fissure* is simply a continuation of the short fissure of the same name on the external surface of the hemisphere. It extends downward and forward to join the colcaine fissure, and it separates the precuneus or quadrate lobe from the cuneate lobe.

The *calcarine fissure* separates the cuneate lobe from the lobus lingualis. Its outline is not important. The *collateral fissure* is below the preceding.

The *dentate fissure* begins below the preceding extremity of the corpus callosum and runs forward to terminate at the urcinate gyrus.

The *Lobes of the Internal Surface* are six in number. They are the marginal, temporal, quadrate, sphenoidal, cuneate and gyrus fornicatus. These are unimportant, except one or two possibly.

The inferior surface of the hemisphere presents a subdivision into three lobes, which get their names from their respective positions, viz., anterior, middle and posterior. In addition to these, we notice, going from before backward, the *longitudinal fissure*, partly separating the two hemispheres.

The *corpus callosum*, is that broad sheet of white matter running transversely across from one hemisphere to the other, and puts them in communication. Injure this and our ideas cannot cross the space so quickly, and therefore we need it for a bridge to allow ideas to cross from one side to the other. Its fibres cross transversely over and radiate toward the cortex, upward and forward and backward, making a great deal of the bulk of white fibres found in the hemispheres. It connects directly the two hemispheres together. What do you cut to separate the hemispheres? The corpus callosum. It is connected with the tuber cinereum by the lamina cinerea.

The *lamina cinerea* is unimportant; it is gray matter found above the optic commissure.

The *olfactory nerve bulb* (or lobe) is a bulbous nerve found on either side of the longitudinal fissure, under the frontal lobe.

The *fissure of sylvius* separating the anterior from the middle lobes and lodging the middle cerebral artery.

The *Anterior perforated space*, which is of a triangular shape, is found at the inner side of the fissure of sylvius and external to the optic commissure.

The *optic commissure* is the crossed fibres of the optic nerves, or point of junction of the same. It is found in the middle line anterior to the tuber cinereum.

The *tuber cinereum* is an elevation of gray matter found between the optic tracts and the corpora albicantia.

The *Pituitary* body is located in the selle Tursica. It is a small reddish vascular mass, oval in form and weighing from 5 to 10 grains.

The *corpora albicantia* are small, round white masses, two in number, about the size of a pea, placed behind the tuber cinereum. They are frequently called the bulbs of the fornix.

The *posterior perforated space* is found between the corpora albicantia anteriorly, the pons varolii posteriorly and the crura cerebri laterally. It is a whitish-gray matter, and its numerous apertures give passage to small vessels.

The *crura cerebri* are two large bundles of white matter, shaped somewhat like a cylinder. They emerge from the pons (as seen before), and pass forward and outward to enter the inferior surface of each hemisphere. These are described with the cord (page 109).

Cerebral Location of Gray and White Matter.

As the peduncles pass upward they, on entering the hemispheres, leave a space or interval, usually called interpeduncular.

These peduncles, as they ascend, *pass through two* large ganglia, composed of gray matter. These are called the *opticus thalamus* and the *corpus striatum.*

Ventricles. In locating the *spaces* or *ventricles* of the *brain*, we necessarily look for their boundaries. These ventricles contain a small amount of liquid (cerebro-spinal), and are lined by epithelium, ciliated in early life. Generally speaking, the *corpus callosum* bounds the space *above* and in *front. Below* by the structures, to be seen later, which fill the interpeduncular space. The upper portion of this cavity is separated by thin membrane, known as the *septum lucidum,* which forms the inner wall of a space called the *lateral ventricles* of the hemisphere. Between the two septa lucida, in the natural position, and the corpus callosum above, we have a narrow space, called the *fifth ventricle.* This is very different from the other *ventricular* spaces in *shape*, also in not

being a *continuation* of the canalis centralis of the spinal cord.

The *Lateral Ventricles* consist of a central cavity or body and three smaller cavities on cornuae (anterior, middle and posterior). They are triangular in shape, and are covered by nucleated epithelium, and bounded *above* by the corpus callosum; *internally* by the septum lucidum; *externally* by the corpus striatum and caudate nucleus; *below* by the fornix and optic Thalamus, corpus striatum, Velum Interpositum and choroid plexus.

The *Third Ventricle* is below the lateral ventricles, but communicate with them through an aperture or canal called the *foramen of Monro;* this *Ventricle* is beneath the septum lucidum and the posterior part of the corpus callosum. It is deep from above downward, but narrow from side to side. It sends a prolongation from its inferior side to the *pituitary body.* From behind, the *aqueduct* of *Sylvius* is seen running from the third to the fourth ventricle. Crossing the third ventricle are three very small commissures (anterior, median or soft and the posterior). These connect the fore-brain directly. Its *lateral boundaries* are the optic thalami; *roof* and *front* by the fornix (ant. pillars), and lamina cinerea, and by the median part of the velum interpositum. *Posterior* by the pineal gland, the posterior commissure and the aqueduct of sylvius. *Floor* is made by the tegmenta of the crura cerebri, the posterior perforated space, the corpora albicantia, the tuber cinereum and pituitary gland. The choroid plexus of this ventricle hang down into it, and the middle commissure crosses it from side to side.

If we make a cross section of the brain by cutting thin sections from above down, we come to an *oval-shaped opening* at the level with the corpus callosum; this is called the *centrum ovale minus.* It is white matter, with numerous minute red dots scattered about, which represent blood vessels. If the brain has been congested, they are dark red spots. Cut deeper and we come to the corpus callosum, and this shows an oval-shaped mass of white matter, enclosed by convolutions of gray matter, which is called the *central ovale of Vieussens.*

The *Corpus Callosum* is connected with the fornix inferiorly; terminates anteriorly at the cerebral peduncles; posteriorly, it ends at the plenium or pad.

The *Optic Thalamus,* which is gray and white matter, and connected to its fellow by the soft commissure, bounds principally the lateral side of the third ventricle. They are somewhat oblong, and rest upon the crura cerebri, which they embrace. The gray matter is within and the white matter surrounds it. It forms the lateral boundary of the third ventricle, *internally. Externally,* it is separated from the corpus striatum by the *external capsule.* We find its superior border free and in the 3d ventricle. Inferiorly the border forms the roof of the descending cornuae of the lateral ventricle. The crura cerebri pass through them shaped somewhat like a flattened cone.

The *Pineal Gland,* a reddish-gray body the size of a cherry stone, which contains no nervous tissue, is found above the aqueduct of sylvius. It has an important interest, however, according to Descartes, as being the *seat* of the *soul.*

The *Caudate Nucleus* is found within the lateral ventricle. It has a tail or surcingle, which continues backward in a thin mass, forming the roof of the posterior horn of the lateral ventricle. It is pear-shaped and is composed of gray matter. Between this nucleus and the optic thalamus is a narrow whitish band of medullary matter called the *taenia semi-circularis*

The *Choroid Plexus* is a very highly vascular fringe-like membrane, found at the margin of the fold of pia mater, within the brain, and also in the floor of the lateral ventricles; it crosses and curves so that it may communicate with the choroid of the opposite side, through the foramen of Monro.

The *Foramen of Monro* is Y-shaped and connects the lateral with the 3d ventricle.

The *Corpus Striatum* is *striped,* hence its name comes from these *stripes.* It is found imbeded in the white substance of the hemisphere, and part is within and part without

the lateral ventricle. The peduncles pass through the corpora striata going upward.

The *Fornix* is a longitudinally arched bundle of fibres composed of two symmetrical halves, which are united together centrally, forming the *body,* but these halves diverge in front and behind, constituting the anterior and posterior pillars. It is curved and parallel to the corpus callosum, to the under surface of which its body is adherent. It is narrow and thick anteriorly, wide and thin posteriorly. It lies on the velum interpositum, and it is separated from the third ventricle and optic thalami by the same. In front, the septum lucidum separates it from the corpus callosum.

The *hippocampus major* or cornu Ammonis is a curved white body which ends in a blunt extremity, on which we find small indentations, somewhat resembling an animal's paw or a ram's horn. It extends the entire length of the floor of the lateral ventricle (middle horn). Its lower extremity is called pes hippocampus.

The *hippocampus minor* is a fold of the cerebral wall, and corresponds to the calcarine fissure on the mesial surface of the hemisphere. Its floor is slightly elevated, and we find it on the inner wall of the posterior horn of the lateral ventricle.

The *pes Accessorius* is a white elevation found between the hippocampus major and minor.

The *Velum Interpositum* is a large vascular triangular fold of pia mater which overlies the third ventricle. It enters through the transverse fissure of the brain and passes beneath the posterior border of the corpus callosum and fornix, but above the corpora quadrigemina, pineal gland and optic thalami. The veins of *Galen* commence at the anterior extremity of the velum interpositum.

The *Ganglia at the base of the brain* are the *optic thalami, corpora striata, corpora geniculata, Locus Niger* and *Corpora Quadrigemina.*

The *Corpora Quadrigemina* are four grayish elevations, which are placed in pairs, the anterior pair, called *nates;* the posterior pair, termed *testes.* These consist of gray matter overlaid by a thin superficial stratum of white fibres. They

are *below* the corpus callosum, *above* the iter a tertio ad quartum ventriculum, two are in front and two behind the third ventricle and posterior commissure. The *nates* are larger and darker in color and ovoid or oblong from before backward. The *testes* are lighter and are more pronounced elevations than the nates; they are hemispherical in shape, or pear-shaped bodies. The *brochia* of the nates and testes are slightly raised white bands, which pass to and are connected with the *optic thalami* and the commencement of the optic tract.

The *valve of Vieussens* is a thin transparent lamina of white matter mixed with gray, which fills in the angular interval between the superior peduncles of the cerebellum. The fibres of the fourth nerve decussate in its substance at its upper portion. It covers the canal leading from the third to the fourth ventricle, forming part of the roof of the latter cavity.

The *corpora geniculata* are small oval elevations, flattened somewhat and found on the outer side of the corpora quadrigemina; they internally do not connect with the optic nerve; externally, however, they do continue with the optic tract.

The Structure of a Hemisphere.

The **hemispheres** are composed of gray and white matter. The *cap* or *cortex* is made of gray matter (mixed, however, with five layers of white and gray), the gray being in excess. Each hemisphere has its own cap of gray substance. These differ in size in different people and races, not at the base, but especially in the upper part. We find the difference in the hemispheres. They are involutions of gray matter at first, then the white matter as it forms in these hemispheres sends some of its fibres right through, dividing it, into two portions—intra and extra ventricular.

The gray matter is found in three groups: (1) In the *cortex;* (2) in the *basal ganglia* above mentioned, and (3) in the *lining* of the internal surface of the upper part of the cerebro-spinal tube. In the walls of the sylvian fissure the gray matter is called the claustrum, and it partly separates

the island of Reil from the external capsule of the corpus striatum.

The central gray matter of the cerebrum is found, then, in the lining of the cerebro spinal tube, which is the remains of the original, ventricle from which, embryologically, the brain was formed; it is continuous with the gray matter of the floor of the fourth ventricle, and also with the gray matter of the cord. The aqueduct of sylvius is also lined with it.

Below we find the canal is somewhat thickened; here the nuclei of the origin of the third, fourth and fifth cranial nerves. The white matter of the cerebrum consists of fibres, varying in size, and are arranged in bundles, which are separated by neuroglia. These fibres are often divided, for convenience, into three systems, depending upon the direction they take, viz: (1) diverging or peduncular fibres, which connect the hemispheres with the medulla oblongata; (2) transverse or commissural fibres, by which two hemispheres are connected together; (3) commissural fibres, which connect different parts in the same hemisphere.

The *Internal Capsule* is representative of the *peduncular* or *diverging fibres*. It consists of a central part, beginning in the cord, and medulla oblongata and from the longitudinal fibres of the pons; then, dividing into two principal branches or trunks diverging from each other, they form the crura cerebri or cerebral peduncles, which ascend into the optic thalami and corpora striata. The greater part of these fibres piercing the corpora striata and separating the lenticular ganglion from the candate nucleus. This is the internal capsule, but it goes further still; a portion only, stop in the optic thalami and corpora striata; the other fibres pass through and arise from them, and run on up toward the cortex of the brain, diverging into what we call corona radiata. The fibres of the corona radiata are connected to nerve cells in the gray matter of the cortex.

The *transverse commissural fibres* connect the two hemispheres together. These are formed by the transverse fibres of the corpus callosum and the anterior and posterior commissures.

The *commissural fibres* connecting the different structures of the hemispheres are of two kinds: (1) associate or arcuate, connecting adjacent convolutions, (2) and the collateral, fibres, connecting more distant parts of the same hemisphere.

CEREBELLUM.

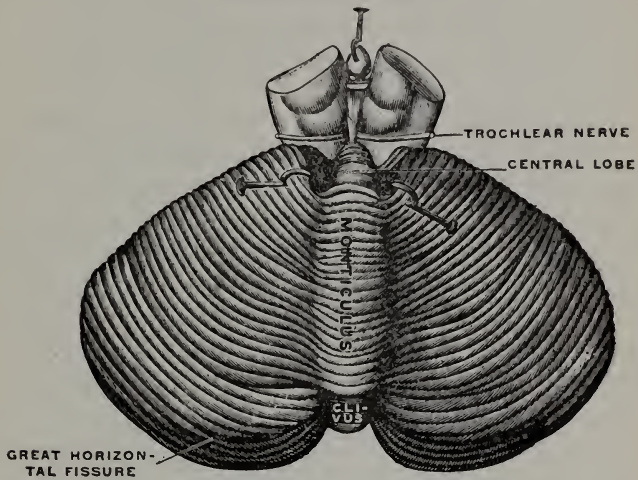


FIG. 37.—Upper surface of cerebellum, showing its shape. Compare with scheme of this surface. (Testut.)

The **Cerebellum** or "little brain" consists of two lateral masses connected together *above* by a median elevation or lobe and separated below by a notch which extends from before backward and receives the back part of the medulla oblongata. It is found occupying the inferior or cerebellar fossa of the occipital bone, beneath the tentorium cerebelli, which protects it from pressure from above, and it also separates it from the posterior or occipital lobes of the cerebrum. It weighs about 3 to 6 ounces; its transverse diameter is from 3½ to 4 inches, and from before backward about 2 to 2½ inches, being ½ inch thicker in the borders than in the center. It is on section in the median line found to consist of gray and white matter, the gray matter being in excess of the white. The gray is external, the white is internal. It is not convoluted like the cerebrum, but it presents peculiarly curved furrows or sulci varying in depth. We see also a characteristic branched appearance, which is

called the *arbon vitae.* The gray matter in the interior of the cerebellum consists of four pairs of nuclei, which are everywhere separated by white fibres from the gray matter of the folia.

The fibres of the cerebellum are for simplicity divided into those which connect the *pons,* those which connect the *cerebral peduncles,* and those which connect with the *autero-lateral tract of the spinal cord,* and the *corpora Quadrigemina* through the *fillet.*

The cerebellar *function* is to direct the movements of the voluntary muscles. When diseased, or injured, the person is unable to execute regular and normal motions, but acts in a confused and peculiar manner, as if in an intoxicated state. The same is noticed in animals; if the cerebellum is removed or injured, they stagger about helplessly. Like the cerebrum, it seems to be devoid of feeling. It has nothing to do with the operations and functions of the mind. Its function principally, then, is to *preside* over *equilibrium.*

The Medulla Oblongata or Bulb.

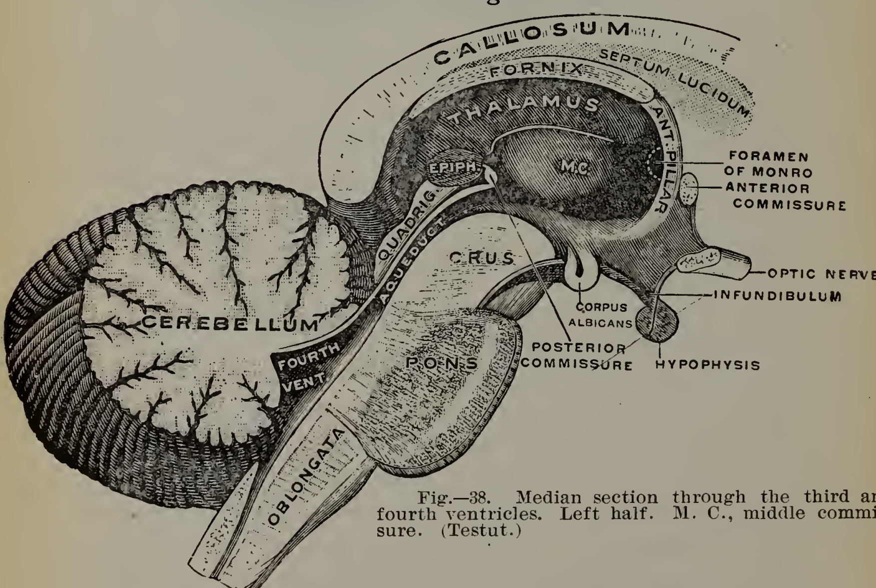


Fig.—38. Median section through the third and fourth ventricles. Left half. M. C., middle commissure. (Testut.)

The Medulla is the prolongation upward of the spinal cord within the skull. It is the enlarged upper part of the

cord, and extends from the upper border of the transverse ligaments of the atlas to the lower border of the pons varolii. It is somewhat shaped like a pyramid, and is 1¼ inches long and ¾ of an inch broad, and ½ inch thick. It is marked in the middle in front and behind by an anterior and posterior median fissure, which are continuous with those of the cord.

The *anterior fissure* contains a fold of pia mater, and terminates immediately below the pons in a culde sac, the foramen cæcum. The *posterior* is a deep and narrow fissure continued upward in the median line, where eventually it expands into the fourth ventricle. These are the fissure which divide the medulla into lateral halves, and thus the shape is formed so that we have to examine an anterior, posterior and two lateral surfaces of the medulla. The base or upper part continues into the pons; the apex or lower part is prolonged into the spinal cord below.

These *lateral halves* are subdivided into minor grooves, into four columns, which from before backward are named *anterior pyramids,* lateral tract and olivary body, restiform body, and the posterior pyramid.

The *anterior pyramids* are two pyramidal shaped bundles of white matter placed on either side of the anterior median fissure. They are separated from the olivary body by a slight depression. They continue below with the anterior column of the cord, at which point their inner fibres decussate with one another across the anterior median fissure. The outer fibres continue upward through the pons, and do not decussate.

The *olivary bodies* are two prominent oval masses, placed behind the anterior pyramids.

The *lateral tracts* are continuous with part of the lateral columns of the cord.

The *restiform bodies* are the largest columns of the medulla. They are continuous with the posterior column of the cord. In ascending they diverge from each other and assist in forming the lateral boundaries of the fourth ventricle, and they enter the corresponding hemisphere of the cerebellum forming its *inferior peduncles.* Other fibres are continued into the cerebrum, forming its peduncles, or crura.

The *posterior pyramids* are white narrow cords placed on either side of the posterior median fissure and separated from the restiform bodies by a narrow groove. They are white fibres and continuous with the posterior median column of the cord. Opposite the apex of the fourth ventricle they diverge from the lateral boundary of the lower part of the fourth ventricle and become lost in the restiform bodies.

The posterior surface of the medulla oblongata forms the floor of the *fourth ventricle.*

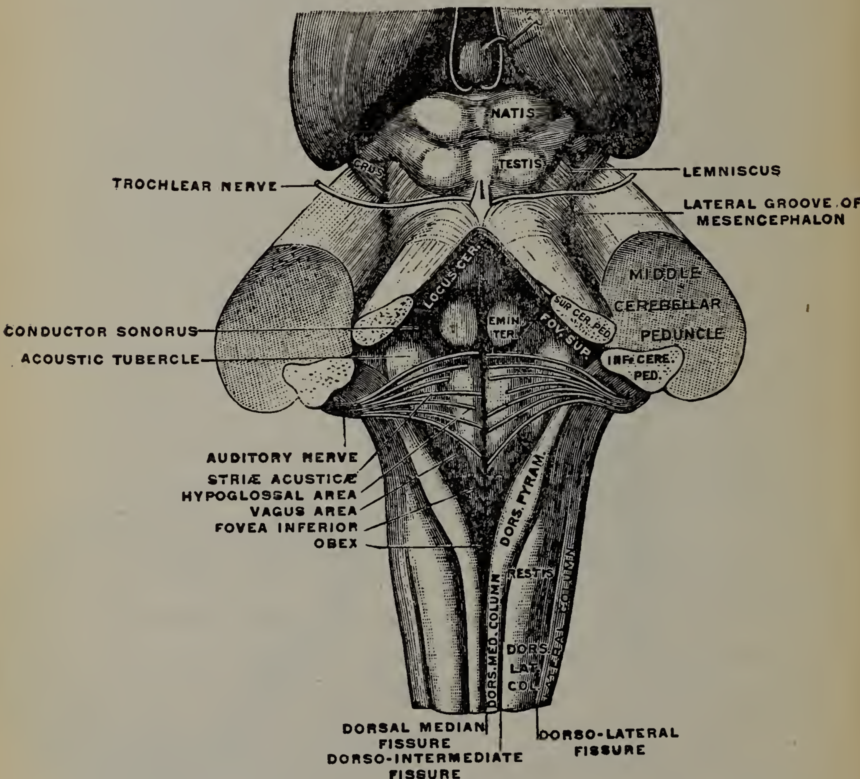


Fig. 39.—Fourth ventricle laid open by removal of its roof. (Testut.)

The **fourth ventricle** is the space between the posterior surfaces of the medulla, and the pons anteriorly, and the cerebellum posteriorly. It is composed of two triangles, with their bases meeting in its center. The *lower* one is formed

by the diverging posterior pyramids and restiform bodies of the medulla oblongata laterally. The *upper* triangle is formed by the process of cerebello ad testes. This lozenge-shaped space has four angles for examination, one superior, one inferior and two lateral angles. The superior one presents the opening of the aqueduct of sylvius, the inferior one is called the calamus scriptorius, or "pen point" angle.

The *roof* is somewhat arched and if formed in its superior half by the valve of vieussens, a lamina of white matter mixed with streaks of gray, which runs across from one superior peduncle to the other. The lower half of the roof is formed by the reflexion of the pia mater passing from under the inferior surface of the cerebellum to the spinal cord. The obex and the ligulæ, also enter into the roof formation, so also part of the lining of the choroid plexus.

The *floor* is a depressed area, rhomboidal in outline, with its long diameter running upward and forward. It is formed by the posterior surface of the medulla and pons. There is a fissure in the median line, on either side of which we find two spindle-shaped longitudinal eminences, the *fascicula testes* These extend the entire length of the floor, and consist of fibres derived from the lateral tract, posterior pyramids which ascend to the cerebrum, and restiform bodies. There are a few white transverse lines, lines transversal, which cross the lower part of the floor of the ventricle. These emerge from the posterior median fissure. Some enter the crus cerebelli; others enter the roots of origin of the auditory nerve, and a few pass upward and outward on the floor of the fourth ventricle. We have besides the above landmarks mentioned a number of little eminences which correspond to the nuclei of origin of some of the cranial nerves; these also are found on the floor of the ventricle, and make most important centers of our many valuable functions of the body.

One of these is noticed on either side of the middle lines close to the inferior angle of the space, which marks the origin of the hypoglossal and spinal accessory nerves. In front and external to this and just behind the fovae posterior is another eminence, which makes the nucleus of the pneu-

mogastric and gloss-pharyngeal nerves. In front of that eminence is another in the same line which is for the nucleus of the auditory nerve, and just in front of these is an elevation, round in character, and immediately behind the anterior fovae, which marks the common nucleus of the abducens and facial nerves.

So that we find important *markings* on the floor of the fourth ventricle. The last ten cranial nerves take their deep origin therefrom or near, and thus raise the dignity of the floor of this ventricle to the highest point.

This medulla oblongata is, then, very similar to the structure of the spinal cord, and conducts both sensory and motor influences. In fact, all of the more important *centers* take their original from the floor of the fourth ventricle, such as the center for *respiration, hunger, thirst, desire for more air., circulation, secretion* of *glands, perspiration, taste, hearing,* etc. It has, indeed, been aptly called the *vital knot.* That nature has placed it beyond harm's reach is shown by its seldom or never receiving an injury from trauma.

The *Pons Varolii* is the part of the brain found in front of the proxymal part of the fourth ventricle. Looking at the base of the brain we notice that it forms a very considerable prominence, which narrows slightly as it passes into the middle cerebral peduncles, or crura. *Inferiorly* the pyramidal bodies are seen disappearing into its substance, and superiorly we notice the cruri cerebri emerging. It rests upon the body of the sphenoid bone, and dorsum sellae, and presents a ventral and a dorsal surface, a superior and an inferior border.

The Pons is the bond of union between the many segments of the fibres and brain. It connects the cerebrum above, the medulla below and the cerebellum behind. It is above the medulla, below the crura cerebri and between the hemispheres of the cerebellum. Its superior surface forms part of the floor of the fourth ventricle and is partly in contact with the corpora quadrigemina. The inferior surface arches like a dutch bridge across the superior part of the medulla and presents a broad transverse band of white fibres extending between the two hemispheres of the cerebellum.

On section we find the pons comprised of layers, alternating transverse and longitudinal, mixed with gray matter, irregularly scattered through the structure.

Cerebral Localization.

By experiments on the lower animals, monkeys, etc., and also through careful analysis of certain injuries of man's brain cap, we can get a fair location of the seat of some of the parts which preside over motion and many other function, specialized. (1) At the superior end of the fissure of Rolando (anterior to the fissure) are the centers of the various convex and irregular movements of the arms and legs in climbing and swimming. On the parietal lobe (anterior to and superior part of the Rolando fissure) is the centre for moving the legs and foot of the opposite side

(2) At the posterior part of the frontal superior convolution anterior to Rolando's fissure, is the center for putting forward the hand and arm, as in prehension or touching objects.

(3) The inferior frontal convolution is the center for moving the lips as in *speaking*. This is commonly called Brocha's convolution; found on left side in right-handed people, and vice versa.

(4) The occipital lobe is for the *visual* center.

(5) The superior temporo sphenoidal convolution is the centre for *hearing*.

(6) The hippocampal region is the location of the centre of *smell* and closely located is that of *taste*.

(7) The centre of touch is located in the hippocampal and gyrus fornicatal region.

Brain Circulation.

The *brain* is supplied with blood by the *internal carotid* and the *vertebral arteries,* two of each. These four arteries at the base of the brain form the circle of Willis; somewhat more quadrangular than circular. The anterior pair or carotids, from which the anterior and middle cerebral arise, and the posterior or vertebral pair, consisting of basilar and posterior cerebral arteries. These also

have sub-communications, which complete the anastomosis, as the anterior communicating crossing from one anterior cerebral to the other cerebral, and the posterior communicating, connecting the middle with the posterior cerebral. Thus these vessels have the very freest anastomosis possible. No other organ is so perfectly supplied with blood; hence, injury to one source of supply does not materially injure the brain, as it can get blood nourishment through another of its aids on the opposite side of the brain. The importance of this fact cannot be over-estimated if we consider that the *arteries* to the *cortex* and to the *ganglia* have *no anastomosis.*

The arteries which supply the *great ganglia* of the base of the brain are called the central or ganglionic arteries. They are usually classed as four main groups; one supplies the lamina cinerea and the caudate nucleus; one supplies the walls of the third ventricle, another supplies the corpora striata and the anterior segment of the optic thalamus. As this last group is the usual seat of cerebral hemorrhage, we term it the most important of the four groups. The last or fourth group supply the external and posterior part of the optic thalamus and the corpora quadrigemina with the cruri cerebri. All these are called *end* arteries, which do not anastomose with any others. Extra of the great circle of Willis blood supply, we find the posterior cerebellar and the anterior inferior cerebellar artery on each side, supplying areas not reached by the posterior cerebral vessels. If we examine more closely we notice numerous small arteries *leaving* the *posterior* cerebral anterior communicating and lateral vessels called *perforating* vessels. These supply independent and localized areas, which are not nourished by the larger main trunks or arteries. All arteries are *tortuous* or *bent* before entering the skull to prevent too much force to the brain centers.

Cortical Blood. We have the same principal, arteries, the anterior, middle and posterior cerebral supplying the cortex, which also formed the circle of Willis and supplied the basal brain. They begin from the base of the brain, reach its lateral borders or surfaces and superior surface or top, freely ramifying in the pia mater and finally supply the

cortical gray matter and the striata of white matter immediately underlying the cortex. The cortex, being itself made up of four or five layers of first gray and then white matter. These vessels give off many large and small branches, and these large ones give off very minute and fine branches. This is because the brain requires nourishment where the large branches are, as well as at their terminations. These large and long minute arteries are called *medullary* arteries, because they pierce the gray cortex and supply also the white matter as well. The ganglionic and cortical systems approach each other very closely, but they do not anastomose, as previously mentioned. We find then, between these two vascular systems a poorly nourished neutral zone or space, which is, according to most mental specialists, apt to undergo *softening* in old age. The blood is deficient there. These vessels are known as terminal arteries; they end without anastomosing; also called end arteries.

Emotions, Health and the Brain. *Joy* and *hope* influence the body and tend to eminently fit it for healthy pleasures, these emotions seldom leading to very dangerous excess. *Hilarity,* says the Book of Health, is a great refresher of the body. *Laughter* is an especially wholesome exercise, beginning at the lungs, diaphragm, thoracic muscles, it continues to the whole body, "shocking the sides," and a jelly-like vibration of the frame, of which we are so agreeably conscious when under its influence. The heart then increases in force and regularity, and pumps the blood rapidly through the smallest and most distant vessels. The face glows with a healthy pink color, the eye brightens, and the animal heat or body temperature is moderately elevated. All of the internal organs increase their healthy action and secrete more readily than if we were solemn and demure. When *hilarity* becomes usual and laughter a second nature, the insensible perspiration of the skin is increased, breathing quickened, the lungs and chest expand, the appetite and digestion facilitated, and as a natural result body nutrition is markedly increased. The old proverb, "Laugh and grow fat," commonplace as it may seem, strikes an important keynote and a highly scientific fact. Shakespeare knew the vast importance

of laughter and describing the nature of "spare Cassius," added, "Seldom he smiles." Lord Bacon said that "The best precept of long-lasting was cheerfulness at meat, and sleep, and exercise." Fear, grief and anxiety are fatal to health, often cause death. In an Eastern apologue a stranger is described on the road going from Bagdad and meeting the Plague. "You have been committing great havoc there," said the traveler, pointing to the city. "Not so great," replied the Plague. "I only killed one-third of those who died, the other two-thirds killed themselves with *fright.*"

To have perfect health, muscles and also mind must be properly exercised. Exercise the memory, and it improves rapidly in power and retentiveness. *When used,* it gives the head and face a full, flushed feeling, which shows that blood circulation is ample and ready to supply any possible deficiency of need. *When unused,* the organ desiccates and loses power to grasp higher thoughts and problems. The brain and nerve tissues generally come under the laws of muscular exercise, and, too, need and necessarily require and demand healthy exercise, or decay follows.

The brain has reflexes as well as the spinal cord. This power of the reflex brain saves the higher centers when the attention is turned toward more important efforts. Some of these we have mentioned in the description of the medulla oblongata, such as coughing, sneezing, winking, laughing, respiration, walking, sitting, dodging and many movements of the musician's hands and feet, with countless other protective movements we undergo when some one tries to tickle or punch our sides, etc. These reflexes all tend to save the brain centers from trivial fatigue and worry. Thus it is that we are able to intelligently cultivate and improve the mind as part of the healthy body and muscular functions. Automatic action of the brain is frequent and necessary for our welfare. We toil and try over and over again to recall some name or prove an intricate problem, and we retire for the night. In the morning we may swiftly do that which the evening before we again and again failed to accomplish. This is its power of spontaneity or automaticity or working of its own accord and of its own manner.

Alcohol and Its Effects Upon the Brain. Alcohol is naturally a stimulant in small doses. It increases the blood supply to the brain and thus enhances its functioning temporarily, or slightly stimulates its activity, as well as that of the heart and circulation. From the habitual uses of alcohol great damage is the result. The brain tissue becomes harder and tougher, its cells begin to waste or desiccate; its general structure appears to shrink and the ventricles become overfull of watery fluid to thus somewhat compensate the deficiency of the more solid material. The alcohol also, by constant use, will weaken the blood vessel walls supplying the brain, and consequently we find disease more apt to attack and rupture these vessels, causing partial paralysis, apoplexy and numerous kindred diseases.

The muscles also undergo changes which result in impaired *tone* or power of the muscle tissue to contract normally. Instead of natural and healthful motions, we have an irregular trembling motion. The hands are shaky, unsteady, even when not used. They frequently after long intervals of drink "shake like an aspen leaf." If you abstain from alcoholic drink and using strong coffee the trembling and desire for spirits will usually disappear.

The *mind* is affected by alcoholic intemperance. It is so affected that often we find mental irregularities and various insanity symptoms present. Loss of memory, sleeplessness, bewildered ideas, delusion, moral senses impaired and reasoning clouded, may result from alcohol drinking. And worst of all is that craving for drink which unveils the man's true evil propensity; this is known as dipsomania or thirst madness. A man in that condition will sell his coat or his most valued relic for enough to buy one small drink. He is mad.

The *will,* which is a part of the mind, is also impaired; this is seen in the loss of self-control. His will is lost for the time being. No man can be self and drink alcohol habitually. After 40 years of age, if man has formed this drink habit, he has not the will power and moral strength to abandon its use.

The *Intellect,* also a part of our mind and the *sensibility* and *conscience* of the man, all are impaired, and often totally destroyed by alcoholic drink. It dries and hardens the body tissue, and causes a thirst which cannot be allayed *except* by more *drink.* It is a mistake to say or think that you can stop the drink habit at will; you cannot. It fastens its prey, and finally masters him, in mind, morals, will and even equilibrium. Many able intellectual giants have fallen through their intemperate use of alcohol. It renders void the "attention, or first quality of reasoning." As a medicine in very small doses it is sometimes needed, but not frequently, however. We may put down as a rule that those who habitually use alcoholic drink, soon "lose all delicacy, courtesy and self-respect." Justice is distorted and unnatural, if acting under the influence of drink.

Dr. or Father Matthew, about 50 years ago, made an estimate in Ireland. The whisky consumption from 1838 to 1842 fell 50% as a result of a temperance crusade. In that same period *crimes* fell from 64,500 to 47,000, about ¼ less, and executions fell from 59 in the first year (or 1838-9) to 1 in the last year. This is proof sufficient for any one as to the evil effects of alcohol habitually. A good authority has said that at least 7-10 of the crime and poverty of the United States comes from the abuse of alcoholic liquors.

Take a quart of common table salt and place on a flat board and leave for a few hours exposed to the air. You will find it later flattened down and very wet. It has absorbed the *moisture* from the *air.* Thus, does alcohol act when taken into the body. *It absorbs the moisture from the tissues of the body* and *causes* a *thirst* which you cannot put off. The danger of the youth's *first drink* is seen here. There is only one safe rule, keep away from drink.

The young most always reply: "It does not hurt me," or "I can stop when I please." This is incorrect. No man can do that with ease. Later in life we notice that some young, healthy man enters the bar and asks for another drink. What is he now? A wreck at 40 years of age. Poor, irri-

table, nervous, palsied, immoral, nerve-dried man or beast, with no will-power beyond getting the liquor which has overpowered him. A sad sight to behold.

The Spartan theory was a good, practical one. The ancient heroes, famed for their prowess and endurance, are said to have killed their new born if they happened to be weak or deformed. And to further prove the necessity of a firmly-knit, strong and normal control of their muscular development, they would have their children congregate in an open space and there intoxicate one of their slaves and allow him to prove to these youths the ill-effects and distortion resulting from drink. It *poisons* the system, thereby inviting diseases of all kinds to enter and feast on our depressed vitality. If a small amount is taken a slight stimulation occurs, which lasts only a brief period; if a larger dose is taken, stupor and trembling occurs, and even death may occur from its poisonous properties. It is said that 8-10 of the inmates of jails and penitentiaries can trace their crimes back to whisky drinking. "Rum did the deed;" "Rum caused me to beat my wife," say these vile creatures before the judge of the court. Try your "health lift" or dyramometer; then drink two ordinary drinks and shortly measure your strength again by the health lift, and you find you are *weaker* instead of stronger. So the alcohol fooled you. It makes you weaker, then, not stronger, as you imagined by your abnormal feeling of prowess.

Alcohol is not the only enemy to the body; we find that tobacco, narcotics, etc., are also tissue poisoners to a large extent.

Tobacco is a common and nauseous habit, especially chewing tobacco. It is a plant freely used and grown in America. Its height is about 2 to 4 feet, with pale green leaves. These leaves are dried and then made into cigars, chewing tobacco, snuff and smoking tobacco.

Tobacco also poisons and irritates the system, and may cause a "tobacco heart" or "tobacco-amaurosis" or blindness, both being extremely common among users of tobacco to excess, or even in some cases moderately. *Nicotine* is the ingredient which does so much damage in tobacco consump-

tion. When used for the first time, nausea, vomiting, vertigo and extreme weakness occurs, and convulsions may result, if persisted in. Place a poultice of tobacco under the armpits and in a few hours *nausea* and sickness will ensue, showing the toxic influence of tobacco even if it have to enter the body through the skin tissue. Athletes are forbidden alcohol and tobacco. It injures their strength, endurance and digestion. Soldiers, often wishing to shirk duty, place tobacco under their armpits, and shortly alarming symptoms develop which keeps them in the sick hospital for some days. This is a trick performed to keep them out of distasteful pursuits. In the Naval Academy tobacco was prohibited after the professors found that it made the students nervous and unsteady or tremulous. You could see the bad effects in their *drawing*.

Cigarette smoking injures, if excessive, by allowing nicotine and re-inhalation of carbonic acid gas to go into the lungs unnecessarily.

Snuff taking injures the voice, the taste and the sense of smell to a large extent.

Narcotics are vegetable in their nature, and are said to quiet pain and cause sleep. Some of them are opium, chloral hydrate, hasheesh and chloroform.

Opium is most frequently used. It comes from the poppy plant, most abundant in India. *Morphine* is its active principal, and we find this forming the important soothing quality of laudanum, paregoric and Dover's powders. Cough syrups and soothing syrups are loaded with this drug, which sometimes kill or injure the baby by too free use. The use of opium may cause that fiendish habit, known as opium eating. It affects the digestive system and nervous centers. That is why we notice an opium eater as lean, sallow and yellow. The will is weakened as in alcoholics.

Chloral Hydrate is produced from alcohol. It has been used for the past 20 years as a sedative or narcotic. Its frequent use also destroys or injures digestion. Hasheesh is, too, frequently used, by those of the past, especially. It comes from the juice of the Indian hemp. Millions of the

East use it, and in Asia the excitement caused by its free use causes a form of furious madness, which often results in murder or some heinous crime. "Hasheeshers" in our language means the same as "assassin."

Chloroform, the best composer of men. It comes from alcohol, and is largely used when surgical operations are to be performed. It may kill and has on several occasions. People who have used opium and other narcotics for their ills and sufferings, sometimes resort to chloroform as their last friend. It is bad and very injurious to the whole nervous system.

Kola nut is a recent drug introduced by the people of the East. They claim that by chewing it, exhaustion and fatigue are prevented. The natives of the East are said to travel for hours without any food or nourishment except the Kola nut, which they chew as we chew tobacco. Americans do not seem to take especial interest in it as yet.

These narcotics are all poison to the nervous centers, through which they injure the digestive system, and finally the whole system.

It is interesting, before leaving the nervous system, to note how, different learned authors have allowed their *habits* to influence their brain stimulus or brain activity in producing their valuable additions to science and knowledge generally.

Three fourths of the idiots born are children of intemperate parents, say these men. And still queerer it may seem, some of the greatest intellects, such as Julius Cæsar and Napoleon Bonaparte, have been great sufferers with brain trouble, called epilepsy, which is often associated with *genius*.

These authors, however, found that various devices were necessary to get at or utilize their subtle genius. All kinds of expedients were resorted to to stimulate or excite their brain centers to act according to their distinguished wishes.

The strong and robust *Victor Hugo* found a *walk* most conducive to the high ideas of thought. The weak and feeble *Descartes* and *Leibnitz* found their happy inspiration

lying down. *Rossini* was inspired only when in bed, stretched at *full length.* *Chateaubriand* found stimulative effects *walking barefooted* around his bedroom. *Bossnet* had to wrap his head up in *warm linen.* *Balzac* felt new light when he put on his *monk's cowl.* *Gautier* only considered himself ready for difficult problems when robed in his *red dressing gown.* *M. Coppee* could not write gracefully unless he wore his *scarlet jacket.* *Perfumes* stimulated *P. Lati* to write nobly, as he said. *F. Cooper* had to suck and *chew gum* to start his brain to work, and *Lord Derby,* when writing, filled his mouth with *cherry brandy.* Emerson said: "I keep a pencil and pad by my bed and when my genius calls me I quickly write it down on the paper, or my shirt bosom, or my cuff, whatever is nearest me receives the brain's efforts in writing."

We know that the spinal cord can be taught to act as in walking, playing and various reflex acts, but it seems, too, as if the brain, the commander-in-chief, the king or emperor of our bodies can too be habit-taught. Should we not, then, beware of those vile alcoholic and narcotic habits? We think so.

CHAPTER XII.

DIGESTION.

This is the process by means of which we are able to take other animal and vegetable structures and utilize for our own tissue building. In order to do this we will find necessary a number of very complicated organs, and also accessory organs so called, from their valuable aid in breaking up and preparing these foods for the more important digestive processes. Thus we are able to supply our muscles with motion and our bodies with heat, etc., from these foods so changed.

Digestion then consists of three processes; *digestion proper* (which includes *mastication* and deglutition); *absorption* and assimilation. These important processes or functions are valuable in themselves, and if they become irregular or diseased our vitality and energy depreciates accordingly.

What is the result of starvation? Loss of vitality, energy and consequently body weight. When an animal loses 4-10 of its weight it dies. Cold-blooded animals live longer, because the process of destruction of its tissues goes on so much slower in them.

The *first tissue* used up is *fat*. Fat people are not supposed to withstand severe attacks of disease so well as lean people. The *next tissue* lost is the *spleen, then* the *muscles.* The walls of the *stomach* and *intestines* lose weight, too, and all the *other tissues* of the body lose weight, even *bone* tissue. The *heart* withstands fatigue longer than any other organ. The *albuminous matter* of the *brain* and *spinal cord* is barely affected at all. Functional activity keeps the circulation and nutrition of the part supplied to a degree. In a *pigeon,* the *feet and leg* bones did not waste so rapidly as the wings and sternum, which were not in use. For the same reason then, the *brain* and *heart* give up last of all the organs; their functional activity keeps them nourished, as they

are constantly acting, and therefore draw the last particle of nourishment which is formed in the body. The inferior parts of the body all contribute the last particle of their nourishment to the higher and more important organism, the brain and spinal cord and heart.

How long can a man starve or go without food? It depends upon the condition of the man when he starts; upon his nervous organism, and upon the manner in which he husbands his strength. A great deal depends upon his ability to make the best use of his stored up food. You can greatly assist the man or animal in starving by supplying artificial heat and keeping him perfectly quiet.

Hunger is not a pleasant feeling unless you know you are soon to gratify it. What tells us that we have enough? A sense of satiety. What causes hunger? An anæmic condition of the stomach. It does not always depend upon a want of food at any certain time, but is a habit. There is a hunger depending upon want of reconstruction material in the body in which we have waste of all the body tissues. This is seen in exhausting diseases, phthisis, starvation, etc. This hunger compels a man to eat most anything or commit most any crime to obtain food. It is this extreme hunger which goes on to hunger delirium, and they lose their power of judgment between right and wrong. You find this all over the world. It is difficult for these men to keep the laws and customs of the land when they are truly hungry. Good men are like good animals; they are only raised on the best of food. Theree meals a day, is from a fictitious hunger.

Thirst is much more exhausting and debilitating than hunger, and we cannot withstand its demands long without delirium and total insanity. Nature indicates her desire for food through a condition of *hunger* or *thirst*. Hunger and thirst are both very pleasant anticipations of something good and refreshing to eat and drink. Dyspepsia or gastritis causes an unnatural or nervous hunger. Other diseases may magnify the same feeling of hunger or thirst.

The want of *water* will destroy the body more rapidly than the want of food. Why? Because we have no extra supply of water on hand, and it is continually being *elim-*

inated by the *lungs, kidneys, skin* and *excreta* generally all over the body, and ceases only with death. The nerve that causes this feeling of hunger or thirst is not located. By injecting water into the veins this thirst feeling can be removed. As in hunger, so in thirst, there are two kinds, real and fictitious. The Americans drink more water, and especially at meals, than any other nation. It is a bad habit to drink at meals to excess; we should take more time to salivate our food. Irritation of the stomach will produce thirst, and is clearly shown in cases of high fevers. Dryness of the fauces also causes thirst. Large hemorrhages and large suppurative tracts will cause abnormal thirst. These are the classes of people who are so much benefited by going to the different springs.

What *Foods* do we require to eat? The same kind and class of things of which our bodies are made, with a few others.

Inorganic salts are as necessary as any other product. We cannot have living protoplasm without the presence of these, especially chloride of sodium, or common salt. It is not true that salt is unhealthy; it is very important in our food mixtures, and at times animals, as well as men, exiled, will risk their lives in hunting and going where salt-licks and salt beds are. The system at times demands this salt food. In the East, children have been seen to suck a small piece of rock salt as if it were candy. To say in Accra, on the gold coast of Africa, "He flavors his food with salt," implies that such a man is rich, for there, salt is rare and is considered a great luxury. A small piece will, in some cases, purchase a slave in that district. An old theory was, to sprinkle the meat with salt was to drive away the devil, and even now, to spill the salt, in America, means, to the layman, bad luck. These salts are obtained from the mineral kingdom and also from certain plants and most all animal tissue which we eat daily.

Water and salts, with lime and iron and potash and a few less important substances, form the essential compounds of our inorganic constituents of the body. These are more

fully described in our consideration of the constituents of the body in previous chapters.

Of course, as the poet puts it, "the *earth* is the mother of all living." In her bosom, and in the atmosphere about her are contained all the elements on which our subtle lives depend.

We have not the power to digest and utilize these crude chemical forms as found in the inorganic world; therefore, the *vegetable world* is needed, and also the *animal kingdom,* to transform and prepare these *indigestibles* to the *digestible* state. These, then, with man, the tester and critic as to the fitness of both vegetable and animal products for the many tissues of the body, are really when simplified, considered as a *food circle* in nature. The vegetable life, utilizing animal exhalations and excretions; the animal life, utilizing the vegetable exhalations and excretions. The plant is nourished by carbonic acid gas and exhales oxygen; the animal is nourished by oxygen and exhales carbonic acid gas. One depends upon the other. Truly, life is a cycle.

*Nitrogenized and non-nitrogenize*d foods are other important classes of food products quite essential to healthy life and adequate nourishment.

Our bodies are, we found, largely composed of protoplasm, and protoplasm being rich in nitrogen, it is therefore essential that we eat large quantities of food containing nitrogen, such as *gelatin, globulin,* and, briefly, albuminoids, which includes *albumen, gluten* and *caseine.* These are so important that they have been called the *"nutritious substances."* These have the property of coagulating or hardening when heated. Warmth and moisture decompose or putrefy them. Cold arrests and protects them from decomposition. Milk and eggs keep longer in the winter than during the warm season. On the coast of Siberia the icebergs bring the bodies of elephants preserved perfectly, after having been caught probably hundreds of years ago in the ice.

Albumen exists in such products as milk, meat, many plant juices, grains, and especially white of egg, which is the most important and purest form obtained. Egg is composed of 6 parts water and 1 part albumen, and this combina-

tion serves to produce such complex tissues as the muscles, bones, organs, claws, feathers, bill and all the varied tissues with which the bird is composed on leaving its shell. Thus we are astounded and deeply impressed with the value of these seemingly simple constituents of the food we eat.

Gluten is found in wheat and grains generally.

Milk consists of water and milk globules. These globules are fatty matter and cause the whiteness by refractive powers of light, the globules being transparent and without color, and without any surrounding membrane. When these globules come together and float we call it cream. By whipping new milk we can get butter as well as if we use cream. It is made by separating the globules from the plasma. The plasma contains that invaluable substance called *caseine.* It differs from albumen only in being alkaline, is alkaline albumen and does not coagulate by heat. It does, however, if left alone. Why? Because it contains sugar, which decomposes and forms *lactic acid,* and this overcomes the alkalinity. This can be prevented by putting in soda, or by placing in zinc vessels, when the acid will attack the zinc rather than the caseine, and lactate of zinc is formed. Milk also contains Na Cl and calcium phosphate, and often when from the animal, it is acid. The fats are the non-nitrogenized principles of milk; fatty matter will absorb flavors; therefore, do not place near onions or other objectionable odors.

These bad flavors may cause the patient to regurgitate or vomit. By skimming, the odor is taken away with the cream, where it finds its way usually. What is it that is nourishing in milk? *Caseine.* Do you find this in the cream? No. This nourishing substance is found in the skimmed milk; therefore, the skimmed milk is more valuable. Milk and especially cream has been known to take up poisonous materials and spread them broadcast, such as Typhoid Fever and Scarlet Fever poisons. A good rule is, never leave uncovered in a sick room. Milk is supposed to be the universal food which can sustain life a longer period than any other substance or fluid. Hence it is considered a *solid food,* as it contains *Potash* in excess of *Na Cl,* which generally proves it to be a *solid* product. We can live longer

on *milk* than any other food; next in importance, *meat,* and third, *bread;* these three are of the highest value in tissue building.

Milk is composed of water, fat globules, caseine, sodium and potash salts, calcium phosphate and sugar. Water does not interfere with the value of milk, if added, except to dilute it and mar its taste. Then the nutrient property of milk depends upon the *caseine,* and not upon the *cream.* Milk varies very little, if any, in its constituent properties in disease or health. It is not conclusively proved that tuberculosis in milk from a tuberculous animal can be transmitted to another animal, unless the said animal has the glands of the udder affected.

Cow's milk and human milk differ considerably. The *cow's milk* contains *more caseine* and *less sugar.* That is why we *dilute* and *add sugar* of milk for children. Cow's milk is not so easily digested as human, hence, it is always preferable to nourish babies with mother's milk, if possible. That which is closest to human milk is *ass's,* and next, *goat's* milk. Boiling milk prevents its coagulation. If boiled daily, you can keep milk a long while. *Clabber* is just as nutritious as milk, if you can digest it. Rennet will produce clabber. The inner membrane of the chicken gizzard will likewise do it. Certain drugs affect milk, and we must be careful in treating the mother lest we injure the child. Bromides and Iodides are the special ones to guard against. *Condensed milk* is good if properly made, and may agree with child when cow's milk does not. *Cheese* is a very good food. Throw down caseine, compress, add salt and let it stand till ripe, and the result is cheese. This at first is not soluble, but after standing awhile it is possible, because it gets alkalinity again from the added salt. *Egg,* we found, consisted of albumen, fat, found in yolk, sugar, salts and water, all necessary products for the nourishment of the embrionic chick or bird, and its feathers, muscles, etc. *To test milk* try the specific gravity. Normal milk has sp. gr. 1030; skimmed milk about 1035 sp. gr.; milk diluted 1-5 sp. gr. 1024. The lactometer tells the amount of cream present.

Meats are derived from the muscular parts of various animals. They contain more or less fat, and are rich in albuminoid substances. This kind of food is very nourishing and easily digested, if eaten fresh. The exceptions to this are veal and pork. Young meat is better than old animal meat. Meat is tough immediately after the killing, but improves if kept a certain time. The fibre is proteid, and in between the muscular fibre is connective tissue, and salts and blood, and extractive material, about which we know little. Meat also has flavoring matter in its tissues, and a sugar called inosit. Meat is almost as good as milk for supporting the body, but in order to get enough of the different ingredients we will have to eat enormous quantities of it. This is why we necessarily have to use a *mixed diet,* to keep us from having to eat such large quantities of food.

Some prefer meat about ready to decompose. Venison is not supposed to be first-class till tainted slightly. The English people prefer meats slightly tainted, and as a rule they eat it rare. Some say that they get their pride and bulldog tenacity from eating uncooked meats. For the same reason animal trainers feed their carniverous pets (lions and panthers) upon raw meats; it makes them vicious and bloodthirsty. Meat should be cooked for a number of reasons. Cooking makes it taste better; therefore, its flavor excites our appetites, and causes secretions generally to increase. It also makes it tender and breaks the tough pieces up into smaller ones, so that the juices can more readily act upon the broken tissues. Fried small pieces of meat in lard is difficult to digest. Poor meat is more watery than that from a fattened animal. So the poor man who buys cheap meat gets less for his money than the rich, who gets the best. To improve the taste, however, the poor man fries his. Beating meat forms a lactic acid, which improves the taste considerably, and hanging in a warm place will do likewise. By boiling meats you get in the water, salts, extractive matters, but no albumen; for this, if any, floats to the top and forms a scum, so do not remove the scum, as cooks generally do, but give your beef tea *muddy*. When clear it has no nutriment of

value. Valentine's meat extract has about 6 grains to the pint bottle. Beef tea does much good, but not as a nutriment; it acts as a stimulant to the heart and nervous system. Nothing better to use after dancing all night or after any exhausting labor. These are better than alcoholic stimulants, and they keep you going until the stomach can get something solid or suitable to digest. The *oyster* is about the only meat used now uncooked. Cooking also raises the temperature of the meat to our body heat, which is good, and it many times, if well cooked, kills any dangerous poisons which may be in the meat tissues. These are often found in chip-beef and pork. Roasting and boiling are the healthiest modes of preparing beef. But in all cases the heat must be strongest at first to close in the juices and keep them from oozing out of the meat fibres.

In Russia they keep meats hanging in the open air for months; they freeze and keep well, and when wanted are sawed like wood blocks.

Trichina, or worms, are found in hams, sausages and many other forms of pork and raw meat; therefore, these meats should be well cooked. The pig muscle is frequently infected with this kind of parasite, which is a minute worm or *trichina spiralis*. By introducing it *alive* into the human body it may cause much damage, as it multiplies very rapidly. In Germany they suffer more of these little meat-worm diseases than in America.

Fish, of course, are largely eaten by all classes of people. We eat the muscles of the fish; just as in meat, we eat the muscle principally. Fish are more watery than meats, yet closely resembling them. The most easily digested varieties are cod, trout and salmon; the most unwholesome and indigestible are clams, the heart of the oyster and the famous lobster, with most of the shell-fish tribe, crabs, etc. Too much fish causes a skin disease, and the mind and body derives very little energy and strength from its continuous use as the principal food of our daily meals. It may even affect some in a peculiar manner; such people should not use fish at all. The row of the fish is very nutritious, and also especially pleasing to the taste.

Vegetables and civilization have always gone hand in hand. They seem to co-exist. This class includes the grains from which we make our breadstuffs, fruits and garden products generally, which covers numerous greens, potatoes, beans, etc. Some of these plants are poisonous, such as strychnia and poppy or opium plants. Also sprouting potatoes possess a poison injurious to our system generally.

The sweet potatoes contain more water and less sugar than the Irish or white potatoes. The tomato belongs to the same class, botanically, as the "night shades," but is not poisonous, excepting the potato when sprouting, as this, too, belongs to the same order.

Bread is next in importance to meat. It comes from the grains, wheat, corn, etc., and is one of man's best friends. These cereals contain starch, fat, gluten and the same salts found in the blood and other parts of the body. Wheat is the principal grain used for food, and has been used for hundreds of years. Because of its nourishing properties, it has been aptly called "the staff of life." Daily we eat bread without tiring of it. The whitest flour is the poorest in gluten principles, and is therefore less nutritious, although it may look better for the table. It is prepared by a process called "Bolting," which separates the chaff or bran from the wheat proper. Unbolted flour means brown bread, because the bran is left in the product; this is called Graham bread. Leavened bread or bread made porous by the use of yeast is most easily digested. Unleavened bread is heavy and requires longer mastication. Hot bread is not so easily digested as cold bread, as it is converted into a heavy pasty mass, which retards the secretion of the digestive juices. The fat found in wheat is not sufficient for the body needs, and therefore we add butter to fill the deficiency. Thus *bread* is called "the staff of life," but "bread and butter" is a gold-headed cane, so called. The health and power of a nation or army, depends upon, to a great degree, the quality of its food. Bread, either leavened or unleavened, has been used and is regarded as a necessary constituent since the time of Moses. All nations demand bread as important parts of diet.

Starch consists of large and small laminated grains, with a nucleus called granulose, and all surrounded by a membrane called cellulose. Treat starch with Iodine and it is colored blue. If subjected to water you get a sticky substance known as gluten. Raw starch is difficult to digest, because the fluids cannot enter through cellulose or membrane. We eat possibly a larger amount of starch than anything else, in the form of bread, corn, cracked wheat, rice, hominy, etc. If not well cooked, as said above, it is seldom digested, and may cause dyspepsia and indigestion generally. Poor cooking produces two American diseases, said Dr. F. T. Miles, dyspepsia and bad teeth. Leguminous foods, beans, peas, etc., contain starch, salts, an extra amount of nitrogenous material, also a substance resembling caseine, and called vegetable caseine, which may be made into cheese.

Fruits are found in great abundance all over our country. They are essential to life, but not necessarily so, for their amount of solid nutriment is small. Cherries contain about 75% of water; grapes, 81%; apples, 82%, etc. These fruits, if digested well, change rapidly their starch to sugar, but *unripe* fruit retards digestion and may cause gastric and intestinal disturbance. Otherwise, ripe fruit assists digestion markedly and stimulates all the digestive juices of the body. Along the shores of the Mediterranean and Southern California, the poorer classes live for months on nothing but a grape diet. *Water,* hard and soft, we discussed in our previous chapter on constituents of the body. Water having passed through lead pipes may be poisonous, as in the case of the royal family of France. The water they drank only had 1-10 grain of lead in the gallon, but 1-3 of the people who drank it were poisoned. 1-100 of a grain has caused palsy. The famous river Thames will at one time dissolve lead, and at another will not.

Coffee, tea, chocolate, etc., are seemingly necessary for the poor man's stimulation. These have alkaloids, *caffeine, theine,* etc., which may or may not assist the digestive functions. They act as gentle stimulants only, and are not foods in any sense. They produce a restful feeling, after having spent a day of effort, and soothes, yet does not disqualify

for labor; therefore, literary workers esteem them highly. Coffee also diminishes the waste of the tissue, and hence assists nature on economic lines. This was tested in Belgium among the miners. They were allowed small amounts of solid food, but with four pints of coffee daily. They were able to withstand fatigue longer and better than other workmen near by. The coffee stimulant is most frequently preferred and used by the caravans which traverse the deserts. Its effect lasts longer than any other stimulant. When taken after meals coffee is also supposed in most cases to act as an aid to digestion. Of black and green *tea* the latter has often proven injurious. The effects are similar to coffee. During Dr. Kane's Arctic expedition the men preferred *coffee* in the morning and *tea* in the evening. Coffee stimulated them during the day and caused them to overcome fatigue, while tea seemed to lull them to sleep in the evening hours.

Chocolate comes from the seeds of the *cocoa tree,* a native of tropical America. It is very rich and nourishing, yet otherwise it resembles coffee and tea in effects. It was called by Linnaeus, the botanist, and its great admirer, "Theobroma, the Food of the Gods." These all are the workman's friends.

Alcohol, Whisky, Beer, etc. We cannot say too much about its horrors, yet there are times when alcohol is necessary; only, however, under a *physician's* directions. In *old wines* there are certain ethers which are very beneficial at times, especially after long weeks of exhausting powers. *Beer* contains a material which often benefits the wearied, weakened system considerably, but it is injurious to the tissues if regularly taken as a beverage.

The *Arabs* are supposed to have been the father of alcohol and its derivations. Its origin, however, is doubtful.

History. Many hundreds of years before Europe knew anything about rice, alcohol was distilled from that cereal. In the year 900 A. D. we read of its being used in Bagdad. The Moors of Spanish territory knew of its quality and they, it seems, spread the knowledge over all Europe. Pliny, the Roman writer, in the first century wrote about a strong in-

flammable wine which was undoubtedly alcoholic in character.

It was described by a Western writer about 1280, who said it was a "burning or ardent water," that came from the distillation of wine. There are possibly 12 members of the alcohol family. Common alcohol is the oldest, and the one which concerns us. It is known, too, as spirit of wine. You obtain it from the grains or from wines by distillation. Brandy, whisky, gin and rum of commerce contain ½ alcohol and about ½ water. Beer, ale and porter contain small quantities. Ripe sweet fruit juices will, at 70°F., begin to "work" or "ferment." Wheat may sprout, and thus its starch is changed to sugar, and later this ferments and alcohol results therefrom.

Alcohol is clear, colorless, volatile, inflammable liquid, lighter than water, and with a penetrating odor and burning taste. It cannot be frozen, hence its frequent use in thermometers for very cold climates. The carpenter uses it in his spirit level and spirit lamp. It burns with a pale, bluish flame, *without* smoke, and with intense heat. It is not a food, but is used at appropriate times as a powerful stimulater for the heart, lungs and viscera generally. It is closely allied to the sugars, yet its effects are widely different from that of the sugars. Sugars nourish, alcohol impairs or breaks down the tissues and makes them weak and unable to withstand great fatigue. For hundreds of years the armies and navies of some of the countries supplied *rum* to each man as a *necessary food.* Of late, tests have been made and we hold that, in hot and cold climates, in active service or at rest, *rum* of any description weakens and debilitates, rather than makes strong or less fatiguing. Sickness and general ill-health resulted from alcoholic uses more frequently than from the absence of it. Therefore, we say, alcohol is not a food, but it injures the food taken otherwise.

Thirst vs. Alcohol. Does it relieve thirst? No. It produces thirst of the worst kind. Place on a flat board, out in the air, a quart of common table salt. In a few hours it absorbs the moisture from the air and flattens out into a semi-fluid mass. Just so it acts in the body tissues, and

alcohol likewise acts the same way by absorbing the moisture from the tissues of the organs and soft parts, which causes a yearning and ravenous thirst which we cannot allay by drinking anything. Thus we find the young man taking another drink and another till stupor overtakes him and he is then in an intoxicated state, caused by alcoholic drinks. It dries and hardens the parts generally, and hence their natural functions are interfered with, just as your tongue, when dry in fever, cannot be so freely used in speaking or singing. Moisture is necessary for free motion and activity. Alcohol does not enable one to resist cold; it deceives you by seemingly raising the body heat, but the thermometer proves the contrary. You lose heat, instead of gaining it. The nerves going to the stomach, have run up to the brain and deceived it by an exaggerated false impression of warmth, while it is irritation and not heat at all. In the campaign of Napoleon in Russia, being exposed to extreme cold, the men testified to the fact that death was hastened by the use of alcohol. The same verification came from the monks of St. Bernard. All arctic explorers rely *not on alcohol* for power and strength to withstand those severe climates, *but fatty food,* even pure oil at times. They avoid alcohol as a great danger.

Alcohol vs. Life. Alcohol poisons life. Plants will not live if brought in contact with it. The animals in the low realm are poisoned by it. If applied to insects and reptiles they usually die within a few minutes, even seconds occasionally. The larger animals resent its forced use in their food or mouths. They show anger if pressed to inhale or drink it.

Alcohol and Its Proper Use. Only as a rare medicine should it be used, and then only at the instance of a physician's directions. It is a rare medicine and dangerous at times. Like arsenic, chloral, opium and numerous other poisons, the physician only should give or order it. It should be placed in the medicine chest and labeled 'poison." It is not *good-fellowship* to ask another to have a drink, but very *bad-fellowship,* for it injures and poisons his system by a drying and hardening process. Their use is not and cannot

be temperate, for it produces weakness, sickness and may be death at times from a very small dose or drink. The author rarely prescribes it, and if necessary, he usually administers it himself, hyperdermically. Bitters often lead to stronger drink after the taste has been sharpened by these co-called bitters found in shops. Some say that pure and good liquors do no harm. All liquors do harm, from the weakest and newest to the oldest and strongest. Pliny, who seemed to know something about everything, said "The very princes do not drink pure wine; to such extent has the villainy of the producers and sellers of wine arrived that we can buy nothing more than the name of a vintage; it is from the very wine vat adulterated, and we may say the poorer wine, the purer." And this from a writer who lived 1800 years ago. The Bible calls it the unclean thing.

The foods and stimulants which we have been discussing are primarily intended for our healthy consumption and final digestion. There are many changes encountered from the first to the last stages of digestion, absorption and assimilation. All of which are highly important and necessary to the welfare of our bodies. Most of these changes are produced by certain juices or secretions of the body, which assist digestion and hence perform the function of *nutrition.* This means supplying each part of the body with its required needs for life and function, respectively.

Nutrition means, then, nourishing the different parts. There are four principal changes which the food undergoes before getting directly at the parts to be thus nourished: (1) *Digestion,* which means triluration, mastication and deglution or reduction of the food to a soluble mass; (2) *absorption* means the process by which we, after digesting the products, take them into the blood; (3) *circulation* is the function which carries the enriched and nutritious blood and its contents to the many and various parts of the body; (4) assimilation, that most important process by means of which each organ and tissue of the body selects from the blood the essential materials for its own individual support, repair and needs. Thus the vital parts are kept alive and in good working order. No machine works with so much precision and regular-

ity as our body-organs, and this is done without noise and without the necessity of reoiling or repairing, except we have an accident and break or lacerate the parts; then we *set* the bones, and may also sew up the flesh wound and dress it; then nature does the rest, just as she produces the chick from the small egg. So, with harmony and a wise delicacy, nature without friction feeds each part of the body, and takes away its waste.

CHAPTER XIII.

ALIMENTARY CANAL.

This is a tube, musculo-membranous in structure, which reaches from the lips of the mouth to the anal orifice, a distance of about 30 feet. In its course it is narrow, dilated, crooked, and at times firmly fixed, at others loose and freely movable. It begins at the lips, therefore, passes through the mouth and fauces, to the pharynx,

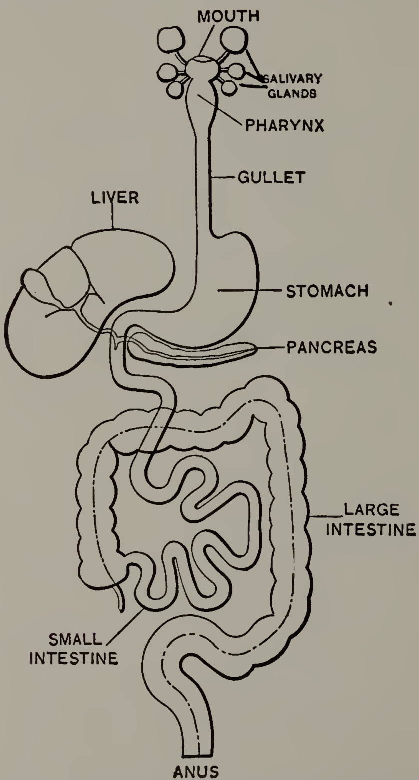


Fig. 40.—Diagram of the alimentary tube and its appendages. (Testut.)

then to the gullet or œsophagus, and then to the most dilated part, the stomach, thence through the small intestine, large

intestine and anus. The stomach and intestines are located in the abdomen and occupy about 2-3 of the space. The foods in passing through these parts are acted upon by two forces, mechanical and chemical. By the *mechanical force* they are churned up, soaked, agitated, softened and pushed onward from point to point; by the *chemical force* they are changed in form through stages, by the power of the different fluids to dissolve particles and prepare them for absorption.

Mastication is the process by which we break the food up, by chewing or mastication. It is placed between the two surfaces of the teeth, and thereby cut and crushed into many very small fragments. The teeth are found in the upper and lower jaws (or mandibles). It is the lower jaw which moves; the upper ones does not move in the process of mastication. The motion is an up and down or cutting one seen in the *cat;* a lateral swing of the jaw on grinding, which is well seen in the cow or camel, and a forward and backward or gnawing motion, seen in the rodents, rats and ground hogs, etc.

The **teeth** are divided into two sets, the milk teeth, or the child's set, 20 in number, and the permanent set, 32 in number for the adult. They are situated in the upper and lower maxillary bones, having roots which project down into certain cavities, called alveoli, which receive and tightly clasp them. The exposed part is the *crown,* which is covered by a protection of the hardest kind of substance found in the body, known as *enamel* Like flint, it is capable of striking fire with steel. The *root and body* of the teeth are made of a very hard substance known as *ivory* or *dentine,* and the root is covered with a substance called *crusta* or *cement* to further protect the dentine. At the margin of the tooth cavity we have a slight constriction of the tooth called its neck, which is firmly clasped and surrounded by a tough tissue known as the *gum.* Within the tooth we find a cavity, and because we find it filled with a highly sensitive pulp, with nerves and vessels intermixed, we call it the pulp-cavity; this cavity has a minute opening at the bottom through which the nerves and vessels enter.

At about 8 years of age the jaws expand and the milk teeth "shed," and their roots are observed after, if not taken out. Then the permanent set, 32 in number, erupt. Each jaw has 8 on either side of the median line; from before

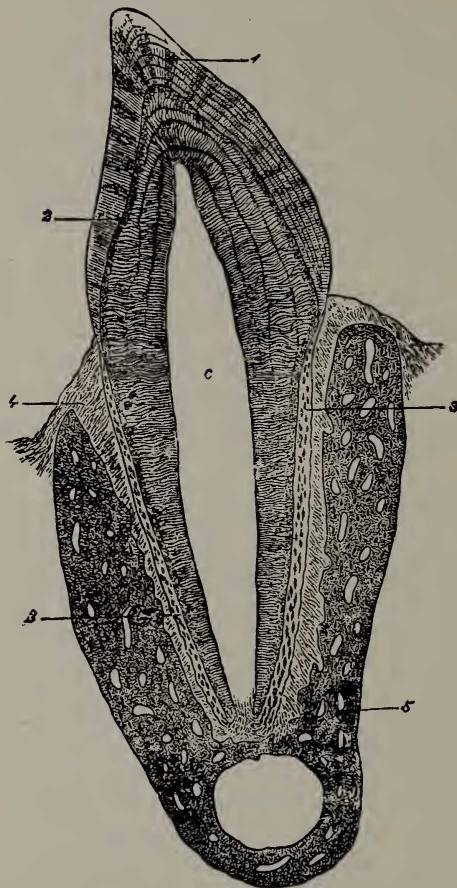


FIG. 41.—Section through a premolar tooth of the cat still imbedded in its socket. 1, enamel; 2, dentine; 3, cement; 4, the gum; 5, the bone of the lower jaw: *c*, the pulp cavity.
Enamel is the hardest part of the tooth and most exposed.
Dentine makes the bulk of the tooth substance.
Cement holds the tooth in its socket.

backward two incisors, one canine, two bicuspids and three molars. The incisors are sharp like a chisel for cutting; the canine is long and round for holding prey, hence canine; the

bicuspids are made with two cusps and are really small molars; the molars are the millers, the grinders or crushers of all hard or soft substances. The last molar is cut when we are about 20 years of age, and is called the "wisdom tooth."

There is a marked difference between the teeth of different species of animals; they are suited, it seems to the respective foods upon which they feed. Take the *carnivora* or *flesh eaters,* the cat, tiger, etc., their teeth are sharp and pointed to seize their prey and to tear it in shreds; in the *herbivora,* or vegetable-eaters, their teeth are broad, blunt, rough-crowned, grinding surfaces for preparing tough grass, corn, fodder and grain. The *rodents* gnaw, so they have curved chisel teeth above and below, usually two or four. But human beings have a mixture of all kinds, they can tear food, hold tightly to meats, eat different kinds of grass or

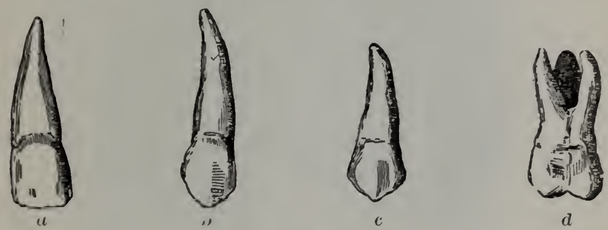


FIG. 42.—*a*, An incisor tooth: *b*, a canine or eye tooth; *c*, a bicuspid tooth seen from its outer side—the inner clasp is, accordingly, not visible; *d*, a molar tooth.

grind cereals or crack nuts, all with ease; the shape of the condyles of the lower jaw has considerable to do with these varied functions.

Care of the Teeth. Cleaning thoroughly after eating will preserve and protect them against decay. If after eating we neglect to clean them, some food particles remain between them and get warm and moist, and putrefy, hence the beginning of decay and bad breath, two defects easily prevented if the child is early taught to clean the teeth well. With this decay, mixed with saliva, a hard crusty fungus grows and sticks to the teeth, known as tartar, are yellow concretions; frequent cleaning with a weak solution of carbolic acid will prevent this formation and dark discoloration. To lose a tooth, and especially a molar, is to "lose a good old

friend," says the hero of La Mancha, Don Quixote. He was once wounded in the face in one of his *great* battles, and after feeling his wounds, found the loss of a tooth, and then he made the above famous remark.

Steel tooth picks, knife blades and the shells of hard nuts break and crack the enamel, and should be avoided, or else you will have decay and cavities formed early in life, and when once broken, the decay travels rapidly through the softer dentine.

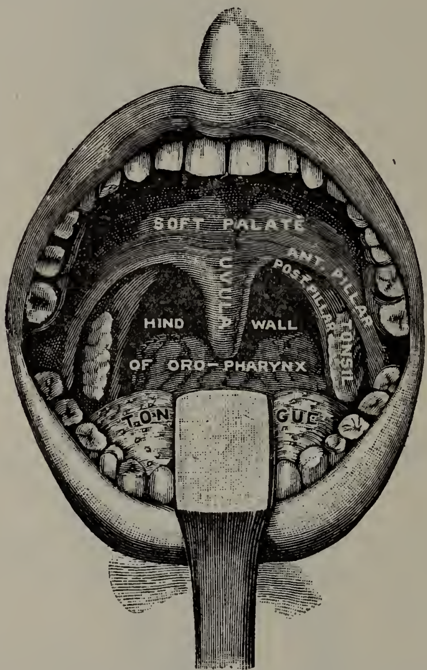


FIG. 43.—The teeth, tongue, soft palate and tonsillar regions. (Testut.)

The tongue is the "miller" that tastes, accepts or rejects, and if acceptable, it turns it over and mixes the food with saliva and keeps pushing the bolus between the teeth so that it may be torn apart, crushed and made into a soft mass, ready for further digestion as it passes on.

The tongue is a huge muscular organ, covered with a mucous membrane, freely movable, endowed with a delicate tactile sensibility, and also being the principal organ of the

special sense of taste, it receiving these terminal nerve endings. It is made of extrinsic and intrinsic muscles, arranged in lateral pairs, with a median raphe. The nerve and blood supply also independently reaches these two lateral halves, and they do not communicate very freely, if at all. Hence,

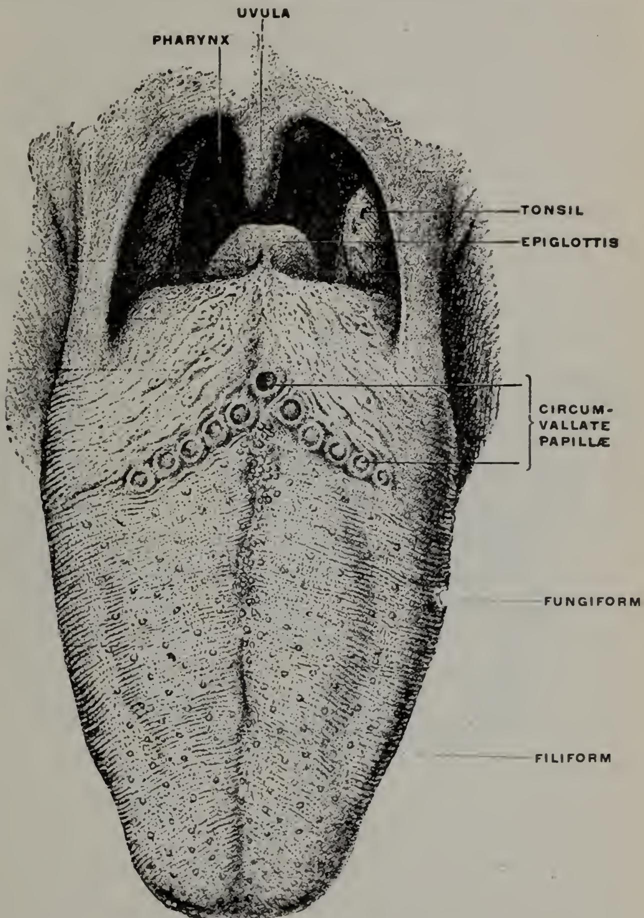


FIG. 44.—Dorsal surface of the tongue. (Testut.)

surgeons can remove part of the organ without interference with the nerve or blood supply of the other. The tongue is found in the mouth between the teeth and attached below to the hyoid bone. It has a root, base, apex, dorsum, lateral

borders and frænum; the upper surface or dorsum is covered with small eminences or *papillae;* these can be readily felt on a calf and cat tongue, being there more highly developed.

The human tongue has three kinds of papillæ, the *circumvallate,* the *fungiform* and the *filiform.* The *circumvallate* are the largest, and are about 7 to 12 in number, placed at the base of the tongue. They are arranged like the Spanish armada, crescentic or V-shaped, with the apex backward and the base forward. Each one is an elevation of the mucous membrane, covered with epithelium and surrounded by a groove or trench. The goblet-like bodies by their sides or within their substance are the *taste buds,* because they give us the special sense of taste. If we care to distinguish a faint substance with little taste, we smack our lips tightly, press hard, with the tongue, so that the substance will be brought in contact with these large taste buds. The *fungiform papillae* are round, elevated, with narrower pedicles or stocks; they are found all over the front and middle part of the upper surface of the tongue. They are very red in color. The *filiform papillae* are most numerous and are the smallest of the three varieties. They are found scattered all over the dorsum of the tongue, except the base. They are cone-like, covered by a thick, horny layer of epithelium, and project upward like tendrils, pointedly. *Carnivora* have these papillae highly developed, so that they may serve to scrape a bone clean even of its tough ligaments. Tamed tigers have been known to draw the blood by licking its master's hand. In feeding a cow with corn from your hand, you have to watch out to keep her from drawing your hand in her mouth by these rough papillae on her tongue. The "fur" on the tongue indicates a derangement of the digestive organs; it consists of a yellowish white coat, mucus, epithelium cells, bacteria, and a general bad taste. A normal tongue should be in infants red, in adults less red, except the tip and edges. The tongue, when the mouth is at rest and closed, fills the whole space. When the alimentary canal is disordered, the tongue being, as the teeth, accessory organs of digestion, will become "furred," and slow to move. The tongue, be-

sides being the organ of taste and digestion, also helps speech; the ancients used to take foreign bodies, cinders, etc., from the eye with the tongue.

The *blood supply* to the tongue comes from the lingual.

The *nerve supply* is complex. *Motor* influences come from the *hypoglossal; sensation,* from the *lingual branch* of the inferior division *of the fifth; taste,* from the *glosso-pharyngeal,* and *sensation* or *motion* from the *chorda Tympani.* Other accessory organs of digestion are the

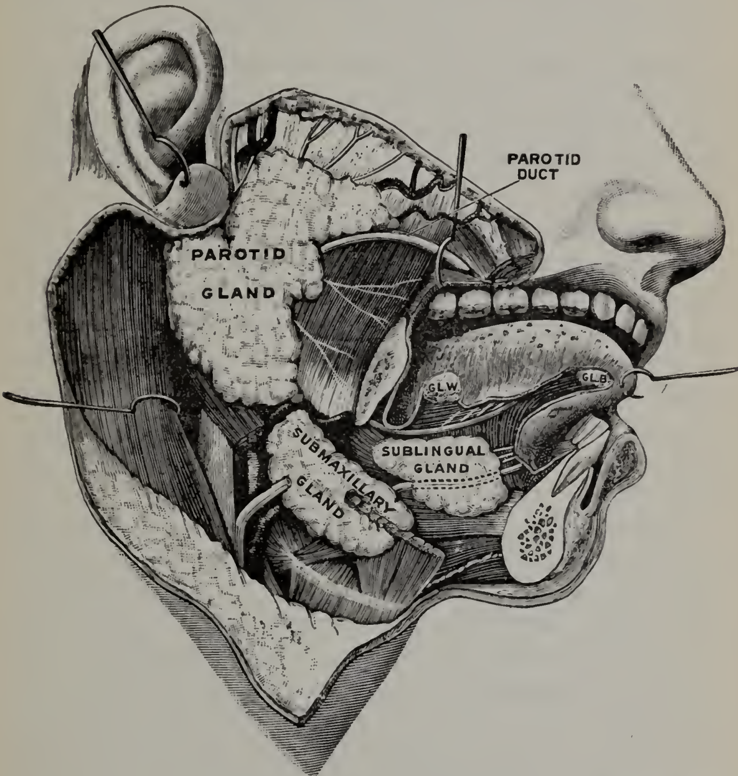


FIG. 45.—The salivary glands. The right half of the body of the mandible has been removed. GL. W., gland of Weber. GL. B., gland of Blandin. (Testut.)

Salivary Glands. They are three in number on each side of the face, and composed of clusters of very small sacs or pouches, around which a delicate network of blood-vessels

is arranged. All of these little sacs empty into larger and larger tubes, till they together form the duct proper which empties into the mouth cavity. These glands are the *Parotid, Submaxillary* and *Sublingual.* The *Parotid* are found in front of and near the area, and behind the ramus of the lower jaw. They weigh about 1 to 1½ ounces, are protected by a rough membrane called the parotid fascia. *Blood,* from the internal maxillary, temporal and auricular posticus, *Nerves;* from the auricular magnus; 7th; auricular temporal and sympathetics. These secrete a serous or watery fluid. Their duct is called steno's duct. It is about the size of a crow quill, crosses the cheek and enters the mouth through the buccinator muscle opposite the upper second through tooth, a finger's breadth below the zygoma. When these glands are inflamed and enlarged we call the disease mumps or parotiditis.

The *Submaxillary Glands* weigh about ℥ii, and are located between the two halves of the lower jaw, in a fossa by the same name, covered by a tough fascia, and communicating with the mouth cavity by its duct, called Wharton's duct. *Its* secretion is *mixed* with *serous* and *mucous* products. Structure is similar to the Parotid. *Blood,* branches from facial and lingual, same as the name of gland. *Nerves,* sympathetic, chorda tympani, and branches from the submaxillary ganglia. Found in submaxillary triangle.

The *Sublingual Glands* are the smallest of the three, and are found under the mucous membrane of the floor of the mouth. Its fossae are below the tip of the tongue, found in the inferior jaw, above the genial tubercles. They are the smallest of the salivary glands, only weighing about ½ to 1℥; they are within the mouth cavity, and have numerous little ducts, from 8-16 in number, called the ducts of Rivini, and one or two connect with one from the submaxillary and form the Bortholin duct. Its secretion is *mucous. Blood,* sublingual from the facial and also submental artery. *Nerves,* lingual branch of the fifth and sympathetic nerves.

The *Fauces* is the opening seen in the back of the mouth, leading from the mouth into the pharynx. It is bounded

above by the soft palate and uvula, below by the root of the tongue; laterally by muscular pillars, covered by mucous membrane, and reaching from the soft palate to the tongue. Each pillar or muscle bifurcates as it goes downward, and in the space between the two we notice a soft, rounded body, the size of a pea, containing numerous glands and filled with small holes; these are the *tonsils*. These tonsils may enlarge if irritated by a cold, and press upon the eustachian tube, which runs from the middle ear to the pharynx, and thus cause temporary deafness, or if chronic, permanent deafness. These small organs can be readily removed, which is done.

Saliva is the result of these salivary gland's secretion; ordinarily these glands only secrete sufficient quantities to moisten the tongue and mouth, but when food enters the mouth the taste or odor stimulates the glands to secrete the saliva more freely. Even the sight of fruits or foods will cause the secretion to increase markedly. This is well illustrated by the small German boy who broke up the girl choir by standing behind a screen as they were about to appear on the stage and squeezing a large yellow lemon so that they could see the juice flow into a glass. Their flow of saliva was so great that they couldn't sing, and had to leave the stage. "Our mouths do water" at times for certain favorite articles of food. Fear, anxiety, grief and numerous other emotions cause this secretion to cease, and then the tongue cleaves to the roof of the mouth for want of moisture. We find in the cow, horse and kindred animals very large salivary glands are proper and necessary to masticate the coarse fodder and grains used as feed. They also have huge muscles of mastication for the same purpose.

Saliva is a thick, glary, frothy, turbid fluid, containing about 5% solids, 2% of which is salts, in which we also find minute quantities of potassium sulphocyanide. It is alkaline in reaction and its sp. gr. is about 1002 to 1006. The mucous membrane of the mouth and the salivary glands together form saliva, and this secretion is *formed* and *regulated* by the nervous system. These glands and epithelial cells differ *during* and after secretion. While secreting they are large, swollen and granular, and their outline is distinct; but when

preparing to secrete they are smaller, transparent and indistinct in outline.

These gland cells do not secrete continuously, but they either do secrete or prepare a substance to secrete, and this substance prepared is not the same substance secreted; for example, peptic cells contain a substance known as *pepsinogen,* which, by the influence of the nerves when secreted is found to be *pepsin.* These are active principles, which seem to act by their *mere presence only.* These *enzymes* or *ferments,* as we will call them, do not produce the *end product* at once, but by various stages. Nor are they used entirely up in their reaction; however, they have a limit in power, and activity. They are like the man in a crowd who creates a disturbance, inadvertently, but seemingly does not enter into the affair at all; he acts, as these *ferments,* by his mere presence only. Saliva is possessed also with such an active principle, we call it *Ptyalin.* What does it do? It acts best in a slightly alkaline media. Cold, retards its action and heat totally destroys its power of action. *Ptyalin* has the property of converting *starch* into *sugar* or *Maltose.* This is accomplished by a series of steps, to dextrose, and from dextrose to maltose. This is a very slow and tedious process, and very little starch remains long enough in the mouth to be acted upon at all. Most of it, we will see later, passes on down to the small intestines, where it is readily changed to sugars. These different actions and secretions are purely reflex in character. Ptyalin can, says a chemist, convert 2,000 times its own weight into sugar; but it is done slowly.

The Nerves Influence Secretion. If the chorda tympani nerve be stimulated the submaxillary gland becomes hyperaemic and a copious watery secretion flows from it; now, stimulate the sympathetic nerve and a scanty thick secretion is the outcome and the gland, instead of being *pink,* as in the former case, becomes *wax white.* The vessels have dilated in the first case, and contracted in the latter one. Hence, we find that saliva differs widely under different influences. *Talking* may influence the quality of saliva, and also the quantity. Lecturing, the same. These centres may be inhibited, too, by fright, anxiety, etc., and we notice saliva

checked suddenly. In stage fright of the early orator he did not *forget* his lines, but the novelty had inhibited his nerve centers and checked his flow of saliva. Hence his mouth was too dry to articulate, and he became embarrassed and ill at ease. Children under 1 year have no ptyalin in saliva; don't require it. Some authors, however, say that the blood vessels have nothing to do with the secretion. For, applying atropine internally and stimulating the chorda tympani we get a hyperaemia *without* a secretion. Therefore, we conclude that the secretion of these cells is under the control of the nervous system, and the secretion differs markedly as the stimulus differs. At one time it is, we found, thin and watery, and at others, it is thick and scanty, and hyperaemia will not cause secretion alone, for atropine will prevent secretion, yet the hyperaemia remains. The *nerves* are the flint and steel that gives the spark to the powder, and the gland cells, *secrete,* just as the powder explodes and we see the smoke and hear the report of the gun.

Glands, then, are formed by involutions of the lining membrane, filled with cells, which rest on a lining membrane or basement membrane, so arranged as to give the greatest secreting surface in the smallest possible space. At rest, we notice an irregular little nucleus, filled in all around with small granules; each nucleus has its nucleolus. Do they fall to pieces when they secrete? No. They begin by filling out, getting plump, and becoming more distinct. How do they look after secreting? They are smaller; the *Duct glands* secrete and empty into channels, often into blood channels. *Ductless glands* secrete and empty directly into the *blood vessels.* Intervals between them greater; nucleus larger, and instead of the granules we find little fibres or shreds of protoplasm. The cell now consists of the nucleus and protoplasm around it; the *granules* represented the material formed by this protoplasm. What happens after the cell has secreted and emptied itself? It immediately goes to work and begins to manufacture more material, no matter what it may be, mucous, bile, pepsin, etc., according to what cell it is. Thus, it is a continual making and unloading of secretion, then rest. How does it come out? Don't know, except

that it comes from the sides, top, bottom, etc., all the same way. How does blood furnish the material for secreting, since it does not leave the capillaries? The blood oozes or exudes through the walls of the vessels, a fluid called lymph. That is all around the cells as well as the vessels. So they get their nutrition from the blood, through the medium, *lymph.* The nature of the gland makes it secrete certain peculiar secretions, and the nerves have nothing to do with that, but they do induce the cells to *give up* their product. Hence we can readily see how the process of digestion may be interfered with by any derangement of the nervous system. It is said that a nerve can be traced directly to each individual cell; that a cell was the termination of a nerve fibre. The reflexes have a great deal to do with secreting. Nerves may be so affected as to seriously poison the gland's secretion, as in a woman's nursing her child in a rage. The bulk of any secretion is water. Where does it come from? It is as much a part of the secretion as the other elements. If a nerve running to a gland be paralyzed or cut, we first have a flow of water secretion, and then the gland degenerates. If things we eat are not just what we want, it is difficult to salivate them; we feel dry and the nerves fail to persuade the glands to give up their contents. Chewing actively stimulates digestion by increasing the flow of saliva; keep the mouth quiet and soon we detect a foul odor. Often seen in fevers and tedious diseases.

The food now on the tongue, mixed with the saliva, is carried back to the pharynx; the soft palate muscles arch and contract, thereby separating the nose cavity by the pharynx coming forward slightly to meet this soft palate, thus completely shutting off the nose communication from above; the larynx is then cut off by the involuntary muscles contracting and pulling upward the box of the larynx firmly against the under surface of the tongue, thereby allowing the bolus of food to pass on over the epiglottis without injury or inconvenience. Only we can't breath while swallowing and vice versa. So to swallow, we have to stop breathing. This act of swallowing is a reflex one. Of course, the lips are first closed. Now, as soon as the food reaches the fauces, it

stimulates the nerves and these cause the act of swallowing, which is a most powerful reflex and quickly sucks the food over the epiglottis into the œsophagus. This is deglutition, or the act of swallowing. This reflex center is found in the medulla oblongata. You get an idea of the force and mechanism of deglutition by watching a cow or horse swallow; then the food is forced rapidly upward against gravity into the stomach. The nerves presiding over deglutition are the fifth pair; which can be stimulated or inhibited. Large morsels of food are more easily swallowed than small ones, comparatively. Our swallowing-reflex, can control other less powerful reflexes; for example, a man will stop breathing to drink water after violent exercise.

Pharynx. This is a conical-shaped organ, with its base upward and its apex downward. It is a musculo-aponeurotic bag about 4½ inches long, reaching from the base of the skull to opposite the cricoid cartilage of the larynx, where it passes into the œsophagus. It is broad from side to side, and shallow antero-posteriorly. Its shape is formed by an aponeurotic bag; inside we have the areolar tissue and mucous membrane, which above the line of the floor of the nose is columnar ciliated epithelium; below, it is squamous epithelium. It has seven openings into it, the two posterior nares; the two Eustachian tubes from the middle ear; the mouth; the larynx, and the œsophagus. Because it is placed behind the nose, behind the mouth and behind the larynx, we name its parts *naso-pharynx, oro pharynx* and *laryngo-pharynx.* It has muscles, constrictors, etc., on the outside of the fibrous aponeurosis, which changes its shape to assist in deglutition. *Blood supply:* Ascending pharyngeal, descending pharyngeal and palatine, and dorsalis linguæ, often. *Nerves*: Pharyngeal plexus of nerves, and the external and recurrent laryngeal nerves.

The pharyngeal tonsils composed of adenoid tissue, found in the vault of the pharynx, frequently enlarge and press upon the Eustachian tubes, thereby causing temporary and often permanent deafness Removal by a curette is the only cure.

Œsophagus. It is a portion of the alimentary canal reaching from the pharynx to the stomach. It is composed of three coats, mucous, muscular and fibrous. The *mucous membrane* is thrown into folds, and is covered over with squamous epithelium. Glands are found over its surface, which secrete mucous to moisten the walls and to allow the food to pass easily. The *muscular coat* is composed of two layers, circular internally, and longitudinal externally. The upper third (about) are voluntary muscles; the lower two-thirds are involuntary. The *fibrous coat* is connected to the surrounding tissues in the neck and thorax. The œsophagus is behind the windpipe, or trachea, and slightly bent laterally to the left. Its action is peristaltic and reflex in character. The pneumogastric nerves control its movements; cut the pneumogastric and the movement ceases. If a peristaltic wave begins, nothing will stop it, though we may have discovered that we are swallowing a poison. *Blood* supply, from the œsophageal of the thoracic, from the gastric, and from the thyroid inferior. *Nerves* are from the spinal accessory through the vagus, and the recurrent laryngeal nerves.

The *epithelium* from the lips to the stomach are squamous in character. From the stomach to the rectum are columnar and cylindrical epithelium.

The *structure* of the *mucous lining* of the alimentary canal is, roughly speaking: First, squamous or columnar epithelium; second, basement membrane; third, fibrous connective tissue; fourth, thin layer of muscle; fifth, connective tissue; sixth, thick muscular layer; seventh, serous (peritoneal), or fibrous. Blood vessels and nerves and lymphatics are found ramifying through these structures freely, especially through the connective tissue.

The Stomach is the most dilated part of the alimentary canal. It is somewhat a conical bag, placed transversely in the upper part of the abdominal cavity. Its larger or cardiac end is found situated on the left side, lying close beneath the diaphragm and fifth, sixth and seventh ribs, near the anterior and medium line. It is placed obliquely, one extremity, the cardiac, being on a higher level than the other, or pyloric end. This pyloric end may in the child hang almost in a

perpendicular position; later on, as the child grows, the fundus enlarges and tends to bring the organ in a more transverse position. It is found in the left hypochondriac and epigastric regions. It is about 12 inches in its longest diameter and from 4 to 6 inches broad, having a pyloric and cardiac orifice. Then we find an anterior and posterior surfaces, and a greater curvature and lesser curvature.

The cardiac orifice is constricted, but it will allow certain reflux movements, and consequently will allow gases and other particles to regurgitate, and finally enter the mouth, and may pass up through the nasal orifices at times.

The pyloric orifice acts as a sphincter; it is made by the circular fibres and the mucous membrane together. It is separated from the diaphragm by the liver, and is lower than the cardiac end. It allows the substances in the stomach to pass on into the small intestine as soon as the movements

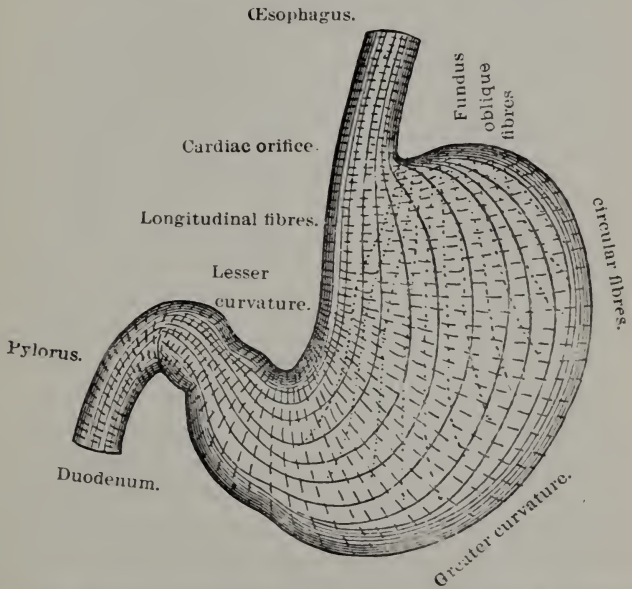


FIG. 46.—Diagram to show the direction of the fibres in the three muscular layers. (Testut.)

and the juices of the stomach sufficiently render the products semifluid; this is done by squirts and at intervals; not all at once.

The curvatures and surfaces are found between the two orifices. There is a slight dilation beyond the pylorus, called the *antrum pylorum*. The lesser curvature is concave; the greater convex. From the latter hangs down a broad fold of peritoneum, which is known as the *great omentum*. It acts as an apron, covering the abdominal contents, thereby protecting them from cold or heat. Usually after 40 years of age, fat is deposited in very large quantities, and is directly responsible for the "fair round belly, with good capon lin'd." The cul-de-sac, or fundus, is found over in the left hypochondriac region.

Structure of the Stomach. It is composed of four coats, external, serous, then going inward is the muscular, submucous and mucous. The *serous coat* is derived from the peritoneum, and it covers the organ almost completely by its two layers. The *muscular coat* is composed of three kinds of fibres, the longitudinal, external, running the length between the curvatures; the circular, found internally, and running in a circular direction around the organ from the cardiac to the pyloric orifice, and help to make the pyloric valve, a real sphincter. The *oblique* fibres radiate from the cardiac orifice downward and toward the pyloric orifice. The submucous coat is composed of loose areolar tissue, which unites the muscular and mucous closely together. The *mucous coat* is a moist, pink membrane, inelastic, and large enough to line the stomach evenly when it is fully distended. Hence, when the stomach is empty and shrunk, its lining is thrown into longitudinal and temporary folds, called *rugae*. It is redder and engorged when the process of digestion is going on, owing to the dilated vessels supplying the organ. The blood is abundant and enters the stomach between the folds of *peritoneum,* which really holds the stomach in place, including the cardiac-end-attachment. The arteries give a few twigs to the outer layers, and then break up into small branches in the submucous coat, from which twigs proceed to supply the network and capilliary arrangement of the mucous membrane. This membrane is composed of a basement membrane covered over by cylindrical epithelium, and it looks velvety.

On examining with a magnifying lens we notice numerous holes or depressions dipping down into the substance of the mucous membrane. They are the so-called glands of the stomach; they are simply involutions of the mucous membrane, to economize space. On their outer part they are lined with cylindrical epithelium; on their sides by parietal cells, and at the bottom by peptic cells. Bowman, a poor, country Canadian physician, first proved that the peptic cells secreted the gastric juice ingredient—pepsin. These cells are called oval, chief or peptic cells. The *nerves* are the pneumogastric, right and left, and also sympathetic filaments. Queer to say, if the pneumogastric is cut, secretion continues; and if they are stimulated, no effect is produced. Yet the stomach is the most irritable organ in the body, except the uterus or ovary.

Stomach Movement. When food enters the stomach it is in a mass; shortly after entering, the stomach contracts in its long diameter, then in the fundus, then in the cardiac extremity, and from there a contraction passes on to the pyloric end. Hence the organ seems to try and get every part of its interior in contact with the bolus of food, *rolling* and *dimpling,* till the mass of food is perfectly saturated and mixed with the gastric juice. The cardiac end contracts more vigorously than the pyloric end. Professor Miles describes the movements of the stomach with the contraction of the hand on a ball contained in it, pressing it on all sides. We see this illustrated well in certain animals, the cow, etc., in whose stomachs, *balls* of hair have been found.

A most interesting and scientific experiment has been performed upon a cat's stomach. Some physician conceived the idea of photographing the cat's stomach while digesting something. He, therefore, mixed bismuth with gruel, knowing that the Roetgen rays would not pass through bismuth, and fed the cat on this, filling the organ. When the X-rays were tried the beautiful outline of the whole organ was watched throughout the whole process of digestion. This was simple, yet very interesting and highly instructive. He later in this experiment rolled a bismuth pellet and gave it, and he could watch its movements throughout the organ

till it passed the pylorus. Queer to relate, the tom-cat could not be induced to take the mixture; he was suspicious; but the female, with a little petting, readily accepted the inevitable and persistent scientist's efforts. These actions last from two to five hours after an ordinary meal. Seldom do we have an empty stomach. Before it is clear of a meal we fill it up again. These movements have a great deal to do with the digestion of the food, by the mixing process, etc.

As fast as the food is acted upon and is ready to pass on through the pylorus, the muscular fibres press it toward the pylorus, and immediately, if suitable for passage, the pylorus opens, and a semi-fluid passes through with a squirt or gush. This continues during digestion in the stomach, but if the food is of such a character that the stomach cannot digest it, it does not remain in the stomach indefinitely; instead, it may be regurgitated up through the gullet and cause vomiting; or, it may irritate the pyloric sphincter and tire it, so that it opens and lets it through into the small intestine.

Some time the pylorus may open too soon and allows the food to pass on undigested; a sedative then may be needed to prevent this too-rapid action.

Dr. Miles calls the stomach an *antiseptic haversack,* which holds and churns the food, but very little more is done with it. If we drink large amounts of water it passes on through the intestines and liquifies the products found therein, and this prevents constipation. The stomach is easily affected by nervous influences. Food, emotion and many other agents, stimulate the stomach to contract. If removed from an animal it will still contract under favorable circumstances.

Vomiting, like swallowing, is a reflex act, and consists of an antiperistaltic movement. The pressure of the abdominal muscles alone will not cause vomiting, unless the sphincter is relaxed. The cardiac orifice relaxes much more rapidly than the pyloric, and may allow the food to come half way up the œsophagus, but the peristaltic *moves* downward and prevents its coming any higher. This *motion* continues even after we have ceased eating. Vomiting is preceded by nau-

sea, eructation of gases, which relax the sphincters; we then deeply inspire, pushing the diaphragm down, fix the chest and contract the abdominal muscles, which with the anti-peristaltic movement, forces the irritating substances up and out of the mouth. If sudden and unexpectedly, it may surprise the soft palate and force its way through the nose, too. It then stings the mucous membrane of the nose by its gastric acid contents. In hysteria, nauseate the stomach; it soon acts beneficially.

In yellow fever the reflex action of vomiting, called antiperistalsis, is all that is required to cause the contents to squirt out of the mouth. This is called *gastric vomiting*. The slimy mucous, lining the stomach of yellow fever cases who died were really protective and not injurious to the patient. It was a protection coat; the black vomit in these cases meant only the mixture of *blood* and gastric juice; not very pleasant, however, to see or vomit up.

We may have a condition where the regurgitation is healthy enough in itself; with the infant, having taken too much milk; it readily comes up, not being painful or pathological, but physiological regurgitation. This is called *cerebral vomiting*. Irregular breathing may cause vomiting, as in seasickness.

Vomiting, however, has occurred after the removal of the stomach, showing that the act is not specially gastric, always.

Secretion. When the stomach is empty the mucous membrane is covered with a thick fluid, which is alkaline slightly (or neutral) in reaction. Immediately after the food has entered the stomach or the stomach has been stimulated, it begins to pour out an acid secretion.

Hyperæmia always precedes the secretion; then if we observe the secretion, we notice that the mucous membrane is bathed in drops of this secretion, which collect at the mouths of the glands, and finally trickle down the walls of the stomach; this fluid is the gastric juice. It becomes abundant by each little gland secreting a few drops; as there are millions of glands, we have, accordingly, millions of drops, which literally bathe the whole stomach surface internally, and then this fluid mingles with the food taken in.

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Gastric Juice is secreted by the many glands of the mucous membrane, which make the internal surface of the stomach appear holy, because of the small openings from these glands. It is a thin, watery fluid, acid in reaction, with a peculiar odor, which usually accounts for the many different odors of vomit; sp. gr. about 1001 to 1006. Free Hcl. gives the acidity to the juice, and this is secreted by the *parietal cells*. This acid should be present in the proportion of 2%. It was once supposed that lactic acid gave the acidity to gastric juice, but it has been fully proven that lactic acid when present comes from the foods *taken*, and is not a normal secretion of the stomach. We have about 12 to 14 pints of gastric juice secreted daily.

It contains two active principles or ferments or enzymes, *pepsin* and *rennet*.

Pepsin, like ptyalin, is a proteid substance, and this seems to act by its presence only. However, it acts only in an *acid* medium, while ptyalin acts in an *alkaline* medium. *Pepsin* acts on proteids; *ptyalin*, on starches slowly. The only test for pepsin is, add Hcl., and see if the two will digest proteids. To obtain pepsin, take a well-washed pig's stomach, strip off the mucous membrane and cut up in small pieces, and place in glycerine; this will extract it and preserve it for some time. Or mix charcoal with gastric juice; it will precipitate the pepsin with it as it goes down to the bottom. Pepsin is secreted by the cells in the *bottom* of the gastric glands, specially, and is found therein, not as pepsin, but a "mother substance," in the form of *pepsinogen*.

Now, we come to gastric digestion, proper, or the preparation of the food for further digestion. Food then, is necessary, and these different juices are also necessary assistants.

The bee lives only a few hours if deprived of food. Rabbits never have a clean stomach, they are always digesting something; and man only has a clean stomach, possibly, just before breakfast. We can digest almost anything if hungry. Greeley's men at one time on their expedition North, ate "moss, chips, leather, and a leather and wood soup," which was digested possibly readily. *Mental* qualities have saved crews on like voyages, one man talking and planning and

stimulating their higher centres will often help them when without food, to hold on a little while longer till help does reach them. Blankets and repose will assist these agencies wonderfully. If healthy and rational, we can call upon our reserved energy, which is fat stored up between our tissues, and withstand exhaustion for days. Not like the Swedish girl who professed to be living without eating, and when watched, really did not eat, and hence died (being, of course, an idiot). She was fat and plump, but her mental powers refused to assist her. One man has lived 53 days without food, but they always drink water. All these different changes, incidentally, are assisted by this peculiar secretion of the gastris, called gastric juice.

Gastric digestion first begins by changing the alkaline ptyalin products to its own acid reaction. This is essential, and must be done in the beginning of its process of digestion or else gastric juice cannot act further.

The *second* step (arbitrarily speaking) is that gastric juice begins to act on the proteids; it swells them up and converts them into acid albumen or syntonin; then step by step the proteids are converted into peptones. Not all of them, but only a small portion are thus acted upon. The gastric juice does not act upon the starches or sugars. It does, say some, eat away the *envelope surrounding* the *fat* globule, but does not act upon the *fat* at all. It acts only on proteids, partially even on proteids, as most of them pass on into the duodenum unchanged. When acted upon they are converted first into *proteoses,* then to *proto-proteoses,* then to *hetero proteoses,* and finally to the ultimate substance, *peptones.* Peptones are thoroughly liquid, and can be detected by Biurett's reaction. See Chemistry.

Gastric juice then is an active antiputrescent and germicide. It has two ferments, *pepsin,* which acts on proteids; *rennet* is a milk-curdling ferment secreted by the stomach, which acts upon the *caseine* of milk and splits it up so that the *lime* salts can act and produce a clot. This is why milk curdles when taken into the stomach, and not because the stomach is "sour," as was once believed; however, too much acidity makes the curd very hard; an alkali should then be administered. The *fats* and *starches* have been left un-

touched by this juice. It *swells* the proteids, and some say, dissolves the envelope of fat; then, lastly, it, in the beginning, changes the alkaline reaction to an acid medium.

What becomes of the sugars? Part forms lactic acid and part is absorbed. Very little known of sugars!

All these acts of the stomach are reflex in character. Place ice over the stomach in nausea, and reflexly, it ceases. So in vomiting. At rest, the stomach is a pale pink color; but as soon as the food enters, it bleaches red and begins to sweat out the drops of juice which bathe its interior. Inject albumen into the veins of an animal and it is thrown off in urine; inject peptones and they remain.

Gastric juice only acts within certain limits of temperature. It differs in different animals. In man pepsin and H Cl will digest not lower than 40°; in a frog or fish they will digest almost at zero. The presence of peptones hinders further digestion, and hence, water drinking about one hour after a meal dilutes these peptones and helps further digestion. Is pepsin ever absent in the stomach secretion? No! Always present. Is H Cl. absent? Yes; and Dil. H Cl. is frequently given to great advantage to patients with retarded digestions. Gluten of bread, if not well cooked, is very difficult to digest. What becomes of the *acid?* It unites with the alkalies of the foods taken. Tonics keep the stomach healthy. To repeat, how do the contents leave the stomach? It squirts; every few minutes the pylorus relaxes and allows the prepared fluid to pass on into the duodenum some digested and undigested.

Why does the stomach not act upon itself and digest itself? Because, say some, its deep alkaline secretion of the cells checks its digestive properties; for gastric juice can only act in an acid medium. Dr. Miles says it is because the stomach is living matter, or a living organ. A dog will digest a living frog-leg, if attached so that the leg is placed in the fluid and the living frog outside, only after the skin and epithelium are removed from it. As long as they remain intact the juice cannot digest it; so, also, with worms, etc. If a man is killed during digestion the stomach will, it is said, digest itself, having lost *its vitality.*

Heart-burn, so-called, is stomach-burn, and is caused by fermentation, which forms lactic acid and fatty acids, which result finally in that hot sensation and eructation of gases.

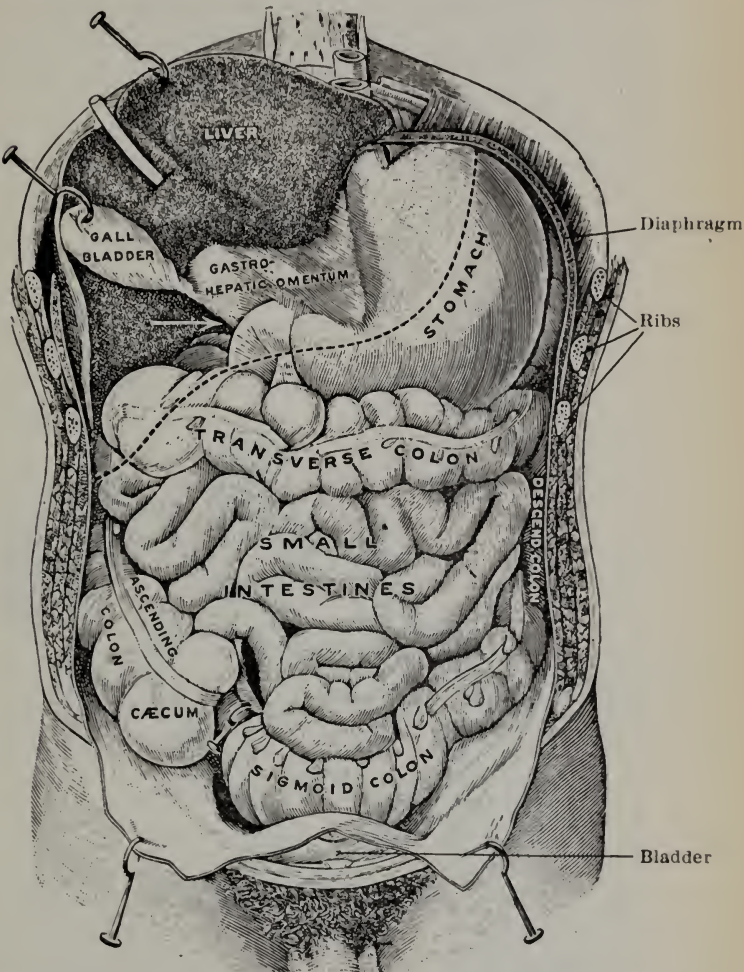

FIG. 47.—The stomach and intestines, front view, the great omentum having been removed, and the liver turned up and to the right. The dotted lines show the normal position of the anterior border of the liver. The dart points to the foramen of Winslow. (Testut.)

How are these processes of digestion verified? Principally by experiments on animals. But to begin earlier: Once a Canadian, Alexis St. Martin by name, received a gunshot

wound in the stomach, which in healing left an orifice about one inch in diameter. Through this window could be watched all the different changes of digestion, and many experiments with different foods were tried. Recently, a physician offered to give his whole body up to a hospital to be operated upon and experimented with for the sake of science, but the laws of our land do not allow such experiments on humans, even with their consent.

Nervous Influence on Secretion. At rest the stomach is alkaline in reaction, but immediately after stimulation by

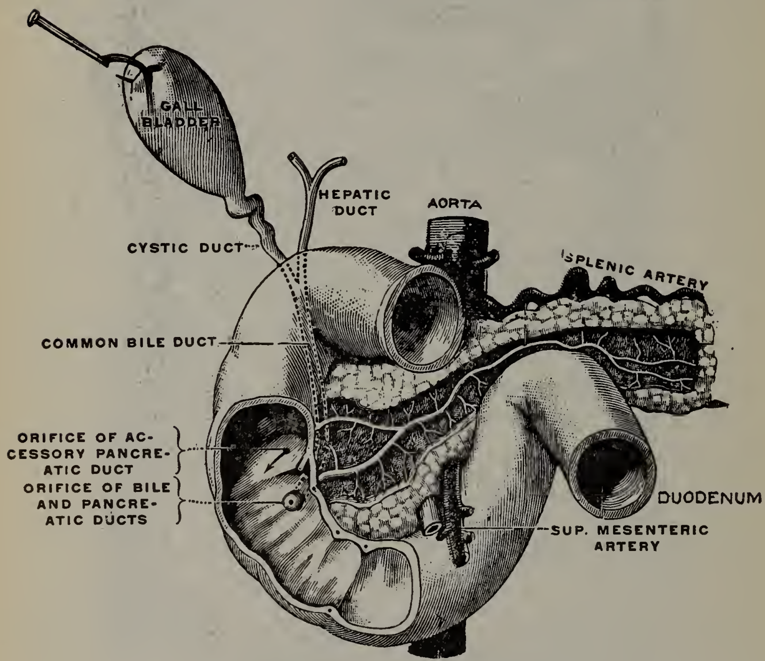

FIG. 47½.—Ducts of the pancreas. Part of the front wall of the duodenum is cut away. (Testut.)

food entering, it becomes acid. Thus the nerves seem to preside over its secretion, and may vary the amount secreted.

Blood supply is rich, and comes, principally, from the gastric pyloric, and branches from the hepatic and splenic arteries.

Nerves of the stomach come from the pneumogastric and sympathetics.

Small Intestines. The duodenum, jejunum and ileum are the divisions of the small intestine. The small intestine commences at the pyloric end of the stomach and ends in the large intestines in the right illiac fossa. It is about 20 feet long and 2 inches wide in the duodenum and something like ¾ of an inch in its smallest diameter. The general structure of the intestine is similar to that of the stomach. It has a mucous membrane, or inner lining, which furnishes the secretions that moisten its walls; a muscular coat, with circular internally and longitudinal fibres externally, which propel, in a wormlike fashion, the food forward. Externally of all these, the intestines and stomach are enveloped in a smooth, slimy, well-lubricated tunic, which allows the utmost freedom of motion within the abdomen. The process of digestion is completed in the small intestines. The large, serves only to receive the indigestible residue of the food, and later to expel it from the body.

The mesentery is a fold of peritoneum running from opposite the left lumbar vertebræ (second) downward to and at the right sacro-iliac symphysis. It holds the small intestine in place, loosely.

The mucous coat is the important structure of the small intestine. It is pink, soft and extremely vascular. Its folds are transverse in direction, incomplete circles like a horseshoe, and they are permanent in character, not temporary, as those found in the stomach. These folds are the *valvulae conniventes.* They begin about two inches from the pylorus, are most numerous and thickest in the jejunum (upper half), and gradually become less conspicuous in the lower half. In the middle of the ileum they finally disappear altogether. So the jejunum is the thickest part of the intestine. These folds increase largely the area or surface of the mucous membrane, and thus gives more space for absorption and secretion. Another function is, they cause a delay in the progress of

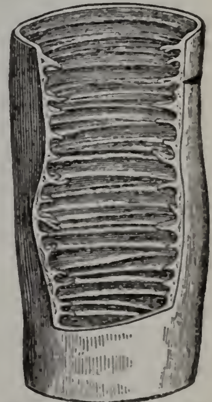

FIG. 48.—A portion of the small intestine opened to show the *valvulæ conniventes.*

the food, and, therefore, give the digestive fluids more time to act and prepare for absorption. They act, then, as an economizer of space, as the convolutions of the brain do by their infoldings. If looked at closely, or with a low-power lens, you notice that these folds are not smooth, but are *yelvety* or *shaggy*. This is caused by the *villi*, which are minute processes, standing up like "pile" or velvet, not only on top of these folds, but on the sides and bottom, and also between them. A villus is about 1-50-1-35 inch long. Many are rounded and shaped like a cone, but most of them are compressed and shaped like a small pedestal, flattened at the base.

A *villus* in structure is complex. A single layer of *columnar epithelial cells* cover it; beneath which we find a frame-

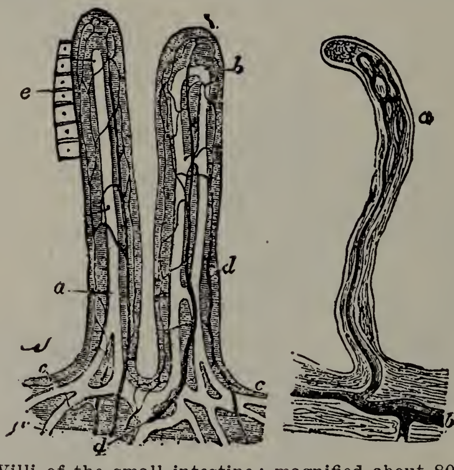

FIG. 49.—Villi of the small intestine; magnified about 80 diameters. In the left-hand figure the lacteals, *a, b, c*, are filled with white injection; *d*, blood-vessels. In the right-hand figures the lacteals alone are represented, filled with a dark injection. The epithelium, *e*, covering the villi, and their muscular fibres, are omitted.

work of connective tissue, called basement membrane; mixed with this near the surface is an incomplete layer of plain muscular tissue, which is continuous below with the deeper layer of muscular tissue found in the mucous membrane. Areolar tissue and spaces, with blood vessels and nerves, are found between this basement membrane and a central vessel, which is an offshoot of the lymphatic system, called, because of its white contents, the *lacteal vessel*, milk-like or white fluid being in it during digestion. These lacteal ves-

sels may be single and conical in shape or may be irregular, like a network formed by two or more vessels with cross branches. These lacteals communicate with larger branches in the submucous coat, which end in trunks that pass out in the mesentery to join the main lymphatic system through the receptaculum chyli, which, with the lymph vessels coming from the lower extremities and pelvis and abdominal regions, join to form one single vessel, called the *thoracic duct,* because it passes up through that cavity to reach the left subclavian vein, where the internal jugular vein joins it; there the contents of the villi and the lymph system empty. At the bases of these villi are numerous arteries and veins, which send prolongations up into the villi themselves.

Between the bases of the villi, opening on the surface of the intestine, are small glands, called the *crypts of Lieberkuhn*. They are similar to the mucous glands of the stomach, being simple unbranched tubes, lined by columnar cells. In the duodenum are minute *glands of Brunner*. They are in the submucous membrane and send their ducts through to the inner surface of the intestine. You can find *solitary glands*, too, in the intestine scattered about, but as they increase in numbers in the lower part of the ileum, and form in groups or patches, we call them *agmanate* or *Peyer's glands*. These are the glands so frequently inflamed in typhoid fever. They are lymphoid in character and structure.

FIG. 50.—Aggregated lymph-nodule of the small intestine (Peyer's patch.) (Testut.)

The *ileo-caecal valve* is where the small intestines joins the large at a right angle and by the two flaps of the mucous membrane, and circular muscular fibres, form the valve, which allows the matter to pass on readily from the ileum into the large intestine, but not the reverse way.

The *duodenum* is the first part of the small intestine, and its most dilated part, as well as its most important part,

physiologically. It is said that we can do without a stomach, but not without a duodenum. The duodenum is about 10 or 12 inches long, curved like a horseshoe, having an ascending, descending, transverse and slightly ascending termination into the jejunum, which is about 7 feet long, and the ileum about 12 to 14 feet long. The duodenum is named from its being 12 *fingers' breadth long; the* jejunum, from its being found always *empty* after death; and the ileum, from its tortuosity and *twisted* state. The duodenum is the greatest center of digestion. It surrounds the head of the pancreas, and receives its duct, which enters at the descending and inner part of the duodenum, in common usually with the common bile duct, which also enters the duodenum. Both ducts bring the secretions of the respective organs, pancreas and liver. The duodenum is under the liver, in the right hypochondriac region. It is, like the stomach, composed of four coats, the mucous coat, as we found, differing somewhat from that of the stomach, in that its folds are transverse and permanent, and it contains villi, and the different glands above described. These glands secrete a fluid known as *succus intericus.* The tortuous course of the duodenum helps to retain the food longer and may facilitate absorption by that fact. The ascending part is the most movable portion, and the lower half of descending and transverse parts are the most fixed. It receives the digested, half-digested and unchanged mass of food which comes from the stomach in squirts; this mass is called by some *chyme.*

The Pancreas, or sweet-bread, is an elongated, soft, lobulated organ, situated behind the stomach, and presents a head, surrounded and held by the duodenum; a tail, closely fixed at the hylum of the spleen, and an intervening portion, the body, situated between these two. It is a compound racemose gland, and of a yellowish pinkish color. The gland was called by the Germans the "abdominal salivary gland," and was regarded of little importance. It weighs about 3 to 6 ounces, and is shaped like a dog's tongue somewhat. The secretion produced by this organ is watery-looking and alkaline in reaction, and is the most important juice for digestive purposes in the body. The duct which brings this secre-

tion from the gland empties into the duodenum, as stated above, and is called the duct of *Wïrsung*. It has many branches, which end in blind pouches, lined with epithelial cells, placed on a basement membrane.

The Pancreatic Secretion is intermittent in character, and it is usually small in amount. It is clear, watery, slightly viscid, and contains very few structural elements; its alkalinity is decided and is due to the presence of carbonate of soda.

Its *enzymes*, or ferments, are three in number, *Trypsin*, *Amylopsin* and *Steapsin*.

Trypsin acts upon proteids. Immediately after the acid chyme passes from the stomach into the duodenum the proteids being precipitated, trypsin begins to act by crumbling these proteids away and by converting the remaining proteids into peptones, also by breaking up peptones, hemipeptones and antipeptones, say some. Antipeptones, according to Dr. Miles, are unacted upon by trypsin, but hemipeptones are broken up into leucin and tryosin. The *peptones* are rapidly absorbed, but not the proteids, till they become peptones by this chemical action of the trypsin.

Amylopsin acts upon starches. We saw that ptyalin of the salivary secretion very slowly acted upon starches. Here we find amylopsin rapidly converting starches to sugars. Sugar is not formed in the stomach naturally, hence giving diastase has little effect beneficially. The starches quickly are converted into dextrin and maltose. Indeed, most of the starches are acted upon by amylopsin and not by ptyalin in the saliva, which converts very little into sugars.

Steapsin breaks fats up into a fatty acid and glycerine. We found that the fats were not acted upon in the mouth, nor in the stomach, except to break the envelope surrounding the fat globules; so we notice in the pancreatic ferment, so-called, the steapsin has the power of acting upon these fats and splitting them up into their component parts, fatty acid and glycerine.

These fats to be absorbed must be *emulsified*, and the presence of a *soap* is of the utmost importance to obtain an emulsion. Therefore, a neutral oil and water will never form an emulsion because a soap can be formed only by the

homely and domestic combination of an acid (usually rancid) and an alkali. After breaking up a portion of the fat, the fatty acids rush for a base in the bile salts and combine with them to form the soaps. Then these soaps envelope the remaining fat globules and form an emulsion. Rancid acids are most easily emulsified because they have already been broken up into their fatty acid and base. Cod liver oil and olive oil, which you can use on your salads, may be emulsified from the same fact. The old slave who saved her meat skins in a barrel, took them out, rancid, put in the old family soap boiler, built a fire under it and when boiling mixed some lye with it and stirred well for a day, then pulled the fire from the boiler and allowed its contents to cool. The following morning she proudly looked and saw a thick scum on the top. In a few minutes this was cut into blocks half the size of a brick and placed on boards to dry for future washings. Is is *soap-emulsion.* The old family darky knew nothing about physiology or the steapsin, but she knew how to make soaps from experience.

What, then, is an *emulsion?* It is a suspension of fine granules of fat in water. The pancreatic juice seems to make a complete emulsion. Is the process of emulsification due to any peculiar process or element? No. It is due mostly to the alkalinity and partly to the viscid character and also to the soap. So, to be absorbed, fat must be emulsified first. Through what channels do they enter the system? Through the villi, and thence through the thoracic duct to the left subclavian vein. The villi prefer fats to peptones, though a few peptones creep in.

The intestinal canal swarms with microbes, and after the pancreatic juice forms its peptones it rapidly decomposes, as do the unabsorbed proteids, and form foeces. Heat and alkalinity in the intestine help this decomposition. Does this not cause many of our indigestions and dyspepsias? The decomposing matter itself may be reabsorbed and thus cause disease. Calomel and salicylic acid are supposed to stop this decomposition and render the intestine antiseptic. So-called pancreatic "tablets" do no good, for the gastric juice destroys them before they leave the stomach.

Succus intericus is a thick, ropy fluid, alkaline in reaction, composed mostly of mucous, and is secreted by the intestines continuously. It selects to act on starches and also converts dextrin, maltose and cane sugar into amylose, maltose and dextrose. Sugar, to be absorbed, must be in the form of dextrose, and this convertion of sugar to dextrose seems to be performed while it is being absorbed. Bile is, we will see later, a very important factor in preventing this putrescence.

We should know that the food in our stomach and intestines is not in our body, properly speaking, till it is absorbed into the blood or lymphatics; then it is a part of us, and amounts to important factors in our body structure

Absorption, then, is our next step, and it is the process by which the body takes up the digested food and, through the blood and lymph, assimilates it. *Diffusion* is the process by virtue of which fluids of different sp. gr. mix together thoroughly. Wet membranes do not prevent this diffusion. A current will pass from one into the other, on the contrary, until they are equal. This is known as *diomosis.* The passing out is *exosmosis;* and the passing in is *indosmosis.* Things which will pass through membranes are *dialyzable;* those which will not pass through are called *colloidal* substances. *Filtration* also has its adherents as to its importance in absorption.

These laws, by most physiologists, are not supposed to be sufficient to explain the real physiological process of absorption. For example, why does not diffusion take place when we hold salt water in our mouth, or why does not the bladder lose all the urinary secretions by diffusion or diosmosis? Kill an animal and examine its gall bladder; you find it is pinkish in color; but if the animal has been dead a number of hours or days it will be a dark green color. Why? Because the dead tissues let the substances pass through them.

Living protoplasm can float in a liquid of most any density and not receive, exchange with or give up to it by the laws of effusion, but if the protoplasm is killed it will immediately swell up. In the case of a patient with cholera

his intestines are thin, but drinking large quantities of water does not seem to help him, as it is not absorbed. So in the eye, we find only a very thin and delicate membrane, which keeps the aqueous humor from the cornea. Immediately after the cells of this membrane die the watery fluid passes into the cornea.

We think, then, that this process of absorption, from the above and other evidences, is specially a *vital act* of the cells. Hydrocyanic acid is absorbed from the mucous membranes of the mouth only after it has killed the cells in the mouth.

Everything that is absorbed gets there by passing through the lymph *channels* or *spaces* first There are no lymph vessels or glands in the brain or spinal cord. Some foods are absorbed within one or two hours, some in five or six hours, and others never.

What is the excrement? Almost entirely the remains of what you have eaten and cannot digest or absorb, such as indigestible products, some that may be digestible, some half digested, some waste, altered bile and water, and possibly some salts and acids and possible foreign substances or bodies. If you find pure bile in the foeces it means that it has been hurried on by purging before it could be absorbed. Drinking water helps to prevent constipation.

Diabetes may be caused by absorption of sugars into the blood. It only occurs from eating too much sugar, and is transient; therefore, it is not a true diabetes. Eggs' white, if unsalted, will not be absorbed. Peptones are not found after absorption; they disappear. Some suppose that they go to the capillaries, by preference, but a few get into the lacteals by chance. The chyle, which is fat suspended in lymph, goes into the nervous system and then to the heart and lungs; while everything else that is absorbed must go first through the liver. Kill or injure the epithelical cells of the intestine or stomach, and there is no absorption. Absorption varies at different times in the same individual. Often the stomach absolutely refuses to act, and the food taken is not passed on to the duodenum, but regurgitated upward as emesis.

The absorbing surface of the small intestine is from ½ to 1 square yard, and the valvulæ conniventes add materially to this estimate of plane surface.

Is work good after a hearty meal? No. The story of the two hounds is well worth remembering. They were both fed early in the morning; one was left home tied up, and the other was taken out to hunt. When the master came

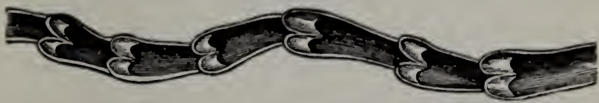

FIG. 51. (a).—Lymph-vessel laid open lengthwise, showing arrangement of valves.

home from the hunt both dogs were killed and their stomachs examined. It was found that the hound which had hunted, still had its stomach full of food, while that of the stay-at-home, was empty. *Moral*: When you have a difficult task to perform, eat little. The more you eat the weaker you will get.

The case of the supposed "living skeleton" was most interesting, because when he died they found that the thoracic duct was closed by disease and absorption by the *lacteals* was thus prevented. His was a rare case of slow starvation. He ate ravenously, but no fats were absorbed on account of the obstruction in the duct.

Food is influenced in its periods of time for digestion by the quality and temperature of the food-stuff, also by the condition of the mind and body; sleep, rest, habit and exercise having a great deal to do with it. Ice-water decreases the temperature of the stomach 30°, and thus checks digestion for half an hour; 100° is the normal digesting temperature of the stomach. Hot food ordinarily is the quickest digested, with the exception of bread and cake; cold food usually reduces the stomach's temperature, and digestion is consequently checked till it warms up again. All nations seem to know this fact intuitively. "It meant death to the Roman slave who brought in his master's water cold or even tepid—so much importance did they attach to hot water as drink." Hot meals mean economy for nature's forces. Rest is desirable and even necessary

after meals, for you cannot eat a hearty meal and write a good letter at the same time unless nature objects and even cries out with pain sooner or later. Force and energy are lost in this division of labor, conjointly. No stomach and brain can work well at the same time. Each requires an abundant blood supply, and if both simultaneously act, each is accordingly deficient of its necessities for best efforts. Experiments have been performed by trying to digest a hearty meal and to sleep during the process; many have died from such rash trials by acute indigestion.

Eating between meals is bad for the stomach, for it needs rest, as well as any other muscle or organ. Violent exercise is injurious just after eating, for the same reason, viz.: the blood is required for the digestive process. Emotion or great grief or excitement checks digestion.

The liver is another organ which pours its secretion into the duodenum, in conjunction with the pancreatic juice, usually about four inches below the pylorus. It is by far the largest gland in the body, weighing from 50 to 64 ounces. It is situated in the upper part of the abdominal cavity, projecting more to the right side than the left, and found in the right hypochondriac region, just below the lower six ribs; the diaphragm is above and the abdominal organs below. It is plump, elastic, slowly indented by pressure, as moulded to the shapes of the organs around by pressure, as when the ribs mark it from tight lacing, etc. Fractures of the liver may occur by sudden jaring from falls or kicks from horses; these, generally, cause death immediately by hemorrhage. The color is a darkish-brown red, and it is friable in texture.

It has five lobes, five fissures, five ligaments and five vessels, and its weight almost reaches five light pounds. So the number *five* plays an important role in the anatomy of the liver.

A deep longitudinal fissure divides the organ incompletely into *right* and *left* lobes, the right being much larger; and on its inferior surface we find three more smaller lobes, marked off by the transverse fissure and other lesser fissures or grooves. The upper surface is convex; its right ex-

tremity is thick and rounded; its left is thin and sharp; the anterior border is sharp and dentated for the round ligament; its posterior border or surface is thick, rough and convex. The peritoneum, and under that the fibrous coat, surround and cover the liver. This last covering is called, only after it begins to enter the liver at its transverse fissure, the *capsule of Glisson.* We find on looking at a cut surface of the liver a granular appearance, and not a homogeneous mass. Each granule is surrounded by a white connective tissue called Glisson's capsule. These granules are the lobules of the liver; and these tiny lobules are composed of small masses of cells, lymph radicles, duct formations and nerves, with numerous capillary blood vessels.

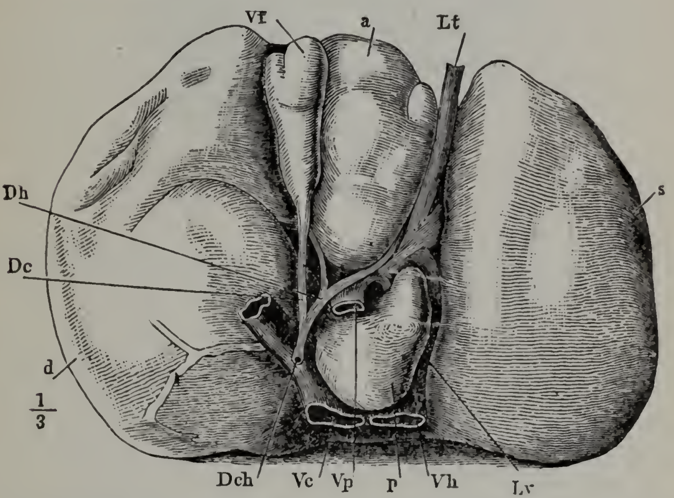

FIG. 52.—The under surface of the liver. *d*, right, and *s*, left lobe; *Vh*, hepatic vein; *Vp*, portal vein; *Vc*, vena cava inferior; *Dch*, common bile-duct; *Dh*, hepatic duct; *Vf*, gall-bladder.

These *lobules* are well shown on a pig's liver thinly sliced and washed out thorougmy. They are about 1-25 to 1-12 of an inch in diameter, and are polygonal in shape, and may be pressed flat or in an irregular shape. *Each lobule* is a little liver in itself and consists of numerous small hepatic cells, separated, as above described, as little granules. These *hepatic cells* are the important tissue elements of the liver, and all else is subsidiarily arranged for their nutrition

and protection. Each cell is nucleated and is about 1-1000 of an inch in diameter and contains also a nucleolus, strands of protoplasm running in different directions, oil globules sometimes and a substance called glycogen.

They are arranged in each lobule in rows and strings; these freely intercommunicate and form a network, in the meshes of which the blood vessel-capillaries run.

Fig. 53.—A small portion of the liver, injected, and magnified about twenty diameters. The blood-vessels are represented white; the large vessel is a sublobular vein, receiving the intralobular veins, which in turn are derived from the capillaries of the lobules.

At the transverse fissure or porta, offsets from the fibrous coverings run in (here called Glisson's capsule) and line the canals, called the *portal canals,* which contain the portal vein, the hepatic artery and the hepatic duct, and thus they tunnel through the organ. These get smaller and smaller as they branch, and finally become indistinguishable when close to the ultimate lobules. These different vessels found in the portal canal break up as the canals do and terminate in minute twigs around the lobules.

Thus the *blood* from the capillaries of the stomach, spleen, pancreas and large and small intestines, taken into the liver by the portal system of veins, is conveyed to a fine *intralobular veins;* these take the blood outside and pour it of the liver, from which the lobular plexus of vein capillaries themselves, unite in the centre of these lobules, to form small *introlobular veins;* these take the blood outside and pour it

into a radical branch of origin of the hepatic vein, and this is called the *sublobular* vein. Every sublobular vein has many lobules emptying blood into it, and by dissecting carefully this vessel, it resembles a bush or twig, with apples attached thereto, by short stalks, well represented by the intralobular veins. From the hepatic veins this changed and much heated blood is carried to the inferior vena cava. The hepatic vein cannot contract, because it fills its liver space.

The *hepatic artery* enters with the portal vein in this portal canal, as seen; and especially ends in the Capsule of Glisson, the walls of the blood vessels, generally; the walls of the bile ducts and lymphatics, and nourishes the liver perenchyma proper; then enters the lobule as *venous* blood, and mixes with the portal blood and comes out, as it did through those various veinplexuses, to the vena cava inferior. It is a branch of the cœliac axis of arteries. Some say that its blood reaches the lobular plexuses as *arterial* blood.

The *bile-ducts* begin as very minute half grooves from the space between two or more cells of the liver. Two cells, then, may be the beginning of a minute bile-duct capillary; these grow larger as others empty into them, till we finally have one from the right lobe, and one from the left lobe, which join and form one hepatic duct; and this meets with the cystic duct and forms the common-bile-duct, which empties into the descending duodenum, often in common with the pancreatic duct. This cystic duct brings the reserve bile, or gall, formed by the liver, and stored up in a pear-shaped sac, called gall-bladder, found in a groove or fissure, under the inferior surface of the liver, and approaching the anterior liver margin. These small bile-ducts anastomose so freely with each other, and send out diverticula, which thus increase materially their size, and help to make small storehouses for the bile all through the liver. Hence, we may term the liver as a large sponge, soaked with bile. These ducts contain muscular fibres, and can contract upon their own contents.

What Does the Liver Do? It secretes bile; makes glycogen; forms urea; raises the temperature of the portal

contents, and modifies the contents of this blood to a considerable extent, even breaking up the corpuscles under certain circumstances. During fœtal life the liver makes red corpuscles; and it is supposed to, in after life, stop the development of ptomaines, which so frequently are formed during the digestive stages, in the small intestine. Arsenic (a poison), when taken is largely found afterward in the liver; and when these irritants are not checked in the liver circulation, dangerous diseases may, later, be caused by them.

Bile, is not viscid; viscidity depends upon mucous; of a brownish yellow color, to a green; sweetish taste at first, then very bitter; musty odor, like cow dung; sp. gr. 1010 to 1050; reaction neutral, or faintly alkaline; and it will not decompose if cleaned of the mucous, but will keep indefinitely. Bile begins to pour out into the intestine, immediately after its secretion; but it may be dammed back in the ducts, and, therefore, over-distend them. If this occurs, the bile becomes stagnant, and is absorbed into the system; consequently, jaundice, or a yellowness, occurs over the body. The white of the eye may be the first organ to be affected by this discoloration.

The bile is not *in* the blood, and simply eliminated by the liver; but the liver cells themselves form it, at the time of secretion. Bile in the blood must get there by absorption; therefore, it seems absurd to say a patient is "bilious." The amount secreted per day is about 1 pint. The viscidity of bile is due to the nucleo-proteids, which come from the epithelial cells, which line the bile ducts.

What are the Constituents of Bile? *Bilirubin,* which comes from hæmoglobin, and colors the human bile; *Biliverdin,* which comes from the coloring matters of the herbivorous animals, and colors their bile green. These, then, are termed *pigments* of bile, or coloring matters. We also have bile salts, *glycocholic* and *taurocholic acids,* which are only found in bile. If *glycogen* and *taurocholic acid* are present, they produce a red color, if H_2SO_4 and sugar are added. Bile also contains some *fats,* and a substance called *cholestrine,* and so-called *leucin. Water,* of course, makes the principal part of bile, as in other secretions. Gall

stones that form in the bladder, and its ducts, by the stagnant bile degeneration, are principally formed of cholestrine and other substances, ealled waste products. Cholestrine is found in the wax of the ear, and nerve fibres, too, Ferrum, and the four salts of the blood, are found in small quantities in bile.

The secretion of bile is a reflex act, usually caused by taking good food into the stomach; but it may be stimulated by certain diseases, abnormally. Blood always seems to be increased in the liver at that time. The quality and quantity of the food taken, influences markedly the amount of bile secreted. There seems to be very little force to press the bile forward from the liver; it just trickles on through, slowly. Hence, clogging of the system of bile capillaries, and consequent stagnation and jaundice. The sluggish circulation of the portal system, may cause it to be absorbed, from this pressure; and the lymphatics in the lobule of the liver then act. We see this in the sad and grieved cases, and it is called "hungry jaundice." A brisk calomel purge, or some other, will deplete the parts of the intestine, stimulate peristalsis, and thus make free the passage of the bile, and consequently relieving the diseased and catarrhal condition of the duodenum.

What Is the Function of Bile? It will not act upon the proteids, starches or sugars. It prefers to act on *fats,* partly *emulsifying* them, but principally it *mixes them* with the two alkaline salts, above named. The fatty acids grab these sodium salts, *forming soaps* (or emulsions), which are soluble, and *set free* the two acids. Some of these fatty acids have been previously set free by the action of steapsin. So its *effect* on *digestion* is *indirect.* Bile helps to *change* the *acid chyme* coming from the stomach to a *neutral* or *alkaline* basis; so that the pancreatic ferments can more readily act upon it. Bile *precipitates* peptones and parapeptones. It *helps* absorption; and is an excellent *antiseptic,* and will prevent meats from decomposing. When *not present* in *foeces,* the odor and color is usually *horrible.* It is a *deodorizer* then, and a *germicide,* and gives *color* to the *foeces* and *urine.* The *Hydro-bilin* colors the foeces and

the *Uro-bilin* colors the *urine*. Lastly, the bile seems to *increase peristalsis,* or the vermicular (wormlike) action of the intestine. When this bile-influence is absent, therefore, we usually have constipation resulting.

The bile and bile salts are formed nowhere else than by a liver cell. What becomes of these? Most of the bile is reabsorbed, and especially are the taurocholic and glycocholic acids, but not the salts. If these acids are not reabsorbed, bile secretion ceases. Put the acids in the blood again and bile begins to secrete as before. Are these now, the same acids? It seems not; some little, however, is lost in the excrement forming in the intestine. The coloring matters are altered as we found above and colored the foeces and urine.

The bile is increased by anything which will increase the flow of blood through the liver directly, or through the portal system. stimulating the splanchnic nerve, momentarily increases the bile secretions, but as soon as the arteries contract, the flow stops and secretion diminishes. When is blood flowing through the liver most abundantly? During digestion. Exercise, helps, too, the quickened flow of blood through the liver. If the other organs of the abdomen are congested, the liver is anaemic, because the blood is held by these organs, and large veins, and only sluggishly flows toward the liver, hence it does not get its proper amount of blood. The liver secretes bile at a very low pressure; it will not rise more than a few mille-metres in the tube. In fatty degeneration of the liver, it stops acting, and the patient looks white and weak. In the "Bilious" stage so-called, the liver is secreting too much bile; because it is not properly used. The patient, has nausea; headache; bad taste; weak; nervous; yellow skin, everywhere, except cornea of eye: bone and cartilage is tinged with yellow; he even sees yellow things, at times.

Rhubarb, Calomel, Nitro-Muriatic-acid and Podophillin will stimulate the liver to secrete more bile than usual.

If the heart, or lungs, become diseased and dam back the blood toward the liver, it causes a congested liver, which is chronic in character. The common bile duct seems suf-

ficiently large to take away any amount of bile, large or small. Bright's disease, Malaria, Carcinoma, etc., may produce jaundice by diseased conditions, but this is not due to bile, but to a poison in the blood, which has caused the change. Meat diet stimulates the secretion of bile more than any other food. Starches and sugars have little, if any, effect. The fats really depress bile formation. The nerves must have great influence upon bile secretion. Some vegetables assist bile formation, by hastening peristalsis, and thus preventing stasis or constipation. We throw off as excrement about 14% of the cabbage eaten; about 20% of turnips, etc.

LYMPHATICS OR ABSORBENTS.

They have thin distensible walls; contain valves; and very freely anastomose with each other; their walls contain muscular fibres, and at various points we find lymphatic glands. Many of these glands are found situated along the course of the chyliferous canals, called the mesenteric glands. These begin by minute tubes with blind ends, which join together and form one or more vessels. Or wherever, we find an interspace between cells—(which we have all over the body)—there is the beginning of a lymphatic. These spaces are all filled with a lymph-fluid. It even forms certain coverings, as in the tunic vaginalis of the testicle, and also certain spaces, too. Around the small arteries of the brain we find lymph spaces. The pericardium, pleura, and peritoneum are lymph spaces or sacs, the largest in the body. Where does lymph come from? It is plasma sweated through the capillary walls of the vessels, and the waste gets into the vessels through lymph medium, by suction, by muscular exercise, and by the vis-a-tergo. The two systems of lymph ducts we noted in our chapter on "circulation." However, they may empty also into other veins of the body. It is the great medium of absorption. If more is poured out than is absorbed, it is reabsorbed. Does it contain anything more than plasma? Yes, it contains all the effete material from the tissues of the body.

FIG. 51. (b).—The regions whose lymph flows into the right lymphatic duct are suggested by the black area; those which are tributary to the thoracic duct by the white. (F. H. G.)

Glycogen is the mother substance that represents the starches; it is found in the liver cells. It seems to readily flash into sugars on the addition of something like saliva, etc. We find glycogen not only in the liver, but wherever we have *active growing protoplasm.* It is purely an animal starch, non-nitrogenized. If an animal is starved, in the last few days of starvation, you will find no glycogen. Now, if you at this last stage give it sugar or starch, you will soon find glycogen in the liver. Glycogen can be formed from a nitrogenized material, and also, we think, from a mixed food. The sugars eaten, supply the tissues, and thus allow the glycogen made to be stored up for future use. Arsenic, will check the formation of glycogen; so also will phosphorus.

How does glycogen leave the liver? Not by the hepatic ducts with bile. It leaves then by the *hepatic vein,* and hence very slowly. Where does it go? To and into the muscles; and while they are at rest, principally. When they act, glycogen is used up. Muscle cells and fibres do not use up their own substance, nor do nerves. But their *fuel,* is the substance used. We see this well illustrated in the engine; it does not use its wheels, pistons, etc., but the coal fuel. The nerves do not get tired. But the muscles do. The microscope does not reveal the difference between the tired and the rested muscle, but the chemist can. The muscles by active action use up glycogen, and form sarco-lactic acid, which makes them tired. It is not strange, then, that the workman requires meat for daily food, mixed with non-nitrogenized substances. There is a sugar centre in the medulla, which if stimulated will cause the formation of sugar. The liver is possibly making a little sugar from its glycogen all the time. Sugar may be found in the urine without diabetes being present; but it may come from a change in the liver circulation, causing congestion and a consequent fermentation, and hence sugar.

Glycogen occurs in the liver in about 4% to 10%, but in a starving animal it is absent.

Fatty substances produce no glycogen; proteids only a little; but starches and sugars produce large quantities.

Sugars produce the greatest amount. Glycogen of the liver passes into the blood as dextrose, about 1% to 2% usually.

More glycogen goes away from the liver as sugar than there is glycogen coming to the liver; therefore, the liver acts as a storehouse for glycogen, and the blood draws upon it when in need.

Ferments readily change glycogen to sugar. Some say that stagnant blood (torpid liver) will cause these ferments. Glycogen is not ordinarily carried *to* the muscles, but it is formed *in* the muscles.

Sugar excess, is taken away by the kidneys; they really act as regulators of the amount of sugar in the body. Stimulating the pneumogastric or sciatic nerves will produce glycosuria, say some. If the pancreas is destroyed, sugar will occur in the urine; but even leaving the smallest piece of pancreas, will prevent this. Sugar diet to excess, may temporarily cause it. Sometimes the tissues, do not properly take up the sugars, then it passes on to the urine.

Urea is formed in the body, but principally in the liver. The liver breaks up proteids into glycogen and urea, step by step. A starving animal's blood will not produce urea, if passed through the liver, but that of a well-fed one, will. Urea is a highly nitrogenized material; for C. H. and O. are taken by the liver in large quantities, forming glycogen and sugar; therefore, there are large quantities of nitrogen left for urea formation. Birds' liver secretes uric acid instead of urea. Take its liver out, and this secretion of uric acid stops; hence the liver only, secretes uric acid, and no other organ, as proven by removal of same.

The liver, then, acts as sentinel in preventing ptomaines, organisms and enemies generally from entering the circulation. It does this by causing the substances to be excreted, or by converting them into a harmless matter. Physic acts upon the liver by increasing the peristalsis of the intestines, and thereby washing away the catarrhal obstruction of the bile ducts, and allowing a free outlet for the bile.

In the portal canals of the liver, we find the portal vein, bile duct and hepatic artery. It may occur that the vein enlarges from too much eating and pressing the bile duct, pre-

venting an outward flow from the liver of sufficient bile for our needs. And also the bile duct may dilate and press against the portal vein, thus checking the supply to the liver.

Tests of Bile. Bile pigments can be detected by putting a drop of the liquid with a drop of nitrous acid. If bile is present, you notice a real rainbow play of colors.

For bile-salts, put a little flowers of sulphur on the surface of the suspected fluid, and if the salts are present, the sulphur falls through as snow; but unless bile salts are present, it will not fall through.

The large intestines are a continuation of the small intestines. They are larger than the small intestines, and are about five feet in length, beginning as a blind pouch, the caecum. Attached to and part of this caecum is a worm-like appendix called the vermiform appendix. It is from 3 to 5 inches long, and has a valve protecting its entrance to the cæcum. In the lower animals it is one or two feet long and large comparatively; in the human, it is about the size of a crow quill. When inflamed we call it the modern appendicitis. Dr. Hershey, of Denver, says that its function is, "to secrete a fluid for the lubrication of the large gut."

The large intestines are thinner than the small intestines; less opaque; less vascular; less glandular; with no glands of Leiberkuhn; no peyer's patches; no villi and no valvulæ conniventes, but they have some few solitary glands. There are villi on the ileo-cæcal valve, but they are found on the ileum side of the valve only. The longitudinal bands, three in number, are shorter than the lumen of the real gut, and therefore throw it into sacculæ; these can be cut, and then the gut can be pulled out straight, and have no sacculæ.

The colon is divided into ascending, and hepatic flexure, transverse and splenic flexure, descending, sigmoid flexure and rectum, which ends in the anal orifice. These parts practically surround the small intestines. From the transverse colon we find in the peritoneal area little fatty bags held close to the gut; these are the appendices epiploicæ. The structure of the large gut excepting the above facts, is similar to that of the small intestines. Its mucous membrane is cov-

ered over with simple columnar epithelium. The large intestines seem to absorb very few things; however, enemata of different kinds are absorbed, so also medicines are readily taken up by the mucous membrane of the large intestines.

Fæces fills most of the large bowel up. Before reaching there it is rendered acid in reaction usually; if not, the large gut being acid, will soon change it. About 4 to 8 ounces of fæces are passed daily; or if a large eater, still more. Fæces contains besides undigested substances, indol, skatol, bile, which colors and deoderizes it, bacteria and exfoliated epithelium.

The rectum is especially formed with semilunar folds, and great distensibility, so that it can hold enormous quantities of waste products It is about 8 inches, (some say six) long, and abundantly supplied with blood, with tortuous veins running upward, and piercing little slits of muscular tissue. At these constricted places compression is frequently made, thus obstructing, partially, the return flow of venous waste blood. This causes the veins to dilate and hence our varices or piles or "emerods," as the Babylonians called them. The rectum has no sacculæ, or appendices epiploicæ.

Rectal congenital malformations are not rare. We may have an imperforate rectum; or one that opens into the bladder; or more rarely still it may open into the vagina. It may be so constricted at its outlet as to admit only a small probe.

The Spleen is a simple ductless gland very closely connected with the portal vessels; in fact, making a great part of the portal vein. The vessels of the spleen have no valves, and hence when the blood is dammed back, it causes congestion of that organ. Dr. Miles calls the spleen a sponge-like organ, for it takes an enormous quantity of blood from a congested liver. It, indeed, is supposed to act as a reservoir for the superfluous digestive blood, or for all the congested internal organs, if necessary.

Anatomically, the spleen is situated in the left hypochondriac region, above the kidney. It is a very brittle, dark red looking organ, which contains a few muscular fibres, and therefore, has the power of contracting on itself and forcing

the blood into the liver when nature dictates through the nervous system. It weighs about 4 to 7 ounces, is somewhat flattened, with an external and an internal surface, convex and concave, respectively; an anterior border, dentated; and a posterior border, convex and round; its hylum is for the entrance and exit of its large vessels, nerves and lymphatics. The butchers call it the "milt." In malaria it may at times enlarge greatly, reaching 40 to 50 lbs. *This is the so-called ague cake.* It is about 5 inches long, 3 wide and 1½ inches thick; it is rounded. Next to the tonsil, the spleen receives the largest vessels in proportion to its size of any organ in the body. It assists digestion, indirectly, by dilating its many trabecular-venous-lined spaces in its substance, and allowing the digestive blood to enter as a reservoir. Uric acid is made in the spleen and we usually speak of the spleen as the place where the red corpuscles die or degenerate, growing old by a process of splitting up, or shrivelling, or even the white ones may change there. Some call it the grave yard of the red corpuscles. In early life the red corpuscles may be generated in its substance, which is somewhat complex.

The spleen is made up of a framework of trabeculae which are lobular in character. These lobules of the human spleen have within them a very delicate network of fibrils continuous throughout the pulp cords and the Malpighian follicles. These fibrils of the entire network, are reticulum, according to Mall. The fibrils encircling the capillary veins are an integral part of this reticulum network, and are not elastic tissues, at all, from Kyes' conclusions.

Alcohol is a poison to natural digestion. It irritates the membranes, dries and hardens them, thus preventing them from freely acting, and hence our numerous classes of dyspepsia resulting from these hardened unnatural mucous membranes from the regular use of alcohol. It is well said that "any drunkard, is a liar." His brain centers have been hardened and the *brakes* are easily reversed, so to speak. *Bitters, cordials, special tonics,* etc., are all alcoholic in character, and are extremely hurtful in themselves, and further, they may lead to the real drink habit, which is horrible.

Absinthe, the Parisian cordial, is fiendish in its resulting effects. It is man's worst enemy in Paris today.

It is in disease, that we use alcohol; not in health.

An observer of the stomach through an artificial window, speaking of the effects of alcohol upon it, said: "It became overcharged with blood; at times drops of blood exuded from it; and its secretions became thick, unnatural and slightly tinged with blood."

The liver, too, is seriously damaged by the alcohol-habit; as are all other organs of digestion. Degeneration or weakening, by over or diseased growth, is the result of drinking alcohol. It also takes away the appetite. The organs forget the sense of hunger.

The kidneys are, like the liver, affected by shrivelling or degenerating, by alcoholic stimulants.

Tobacco is almost as bad as alcohol, in causing dyspepsias and kindred diseases. It dries the mouth, throat and stomach, and causes thirst.

CHAPTER XIV.

RESPIRATION.

To be clean, is to be hygienic. In order to keep the system clean and in a good healthy condition the human requires a number of varied and complex organs, aside from his extremities as organs of prehension and modifiers of our crude surroundings.

Cats make the most careful and painstaking toilets of all the animals, probably except the opossums. Lions and tigers wash themselves, somewhat like the cat, but not so carefully. They wet the dark, india-rubber-like ball of the forefoot and the inner toe, and pass it over the face and behind the ears Thus, the foot is used as a face and head sponge, and brush; and the rough tongue is used as a comb for the other parts of the body. Man, of course, has the advantage in knowing how to employ soaps, washes, etc., for skin purging. When we go to the interior of the human body we find the lungs, the kidneys, the liver and the intestines, are employed to take in and give up certain needed substances and wasted and hurtful products.

Respiration means the gaseous reception, distribution and elimination of the body. These interchanges between the blood and air are known as *external respiration.* While the process of interchange of the systemic capillaries, or where the oxygen is fixed and the carbonic acid gas formed by the tissues, is called Internal respiration. We will study external respiration, or the function of cleanliness by the lungs and adjacent organs. The human, having its blood passing from the right ventricle of the heart, through the lung capillaries, to the left auricle, loses carbonic acid gas, and gains oxygen. In the systemic circulation the reverse takes place—oxygen leaves the blood and supplies the living tissues; and the carbonic acid gas, being generated by these tissues, passes back into the blood capillaries. These changings of the two gases, mean also change of the color of the blood from a *bright red* to a *dark purple-red;* hence from

arterial to venous. The function of the lungs is to change the *dark purple venous blood* to the *bright scarlet arterial blood.*

Living tissue action keeps blood poor in oxygen, but rich in carbonic acid gas, and when this blood comes in contact with, or in close proximity to a surrounding medium, certain gaseous interchanges take place; this may be the atmosphere, or it may be the air in solution of water.

In the lower animals, aquatic in nature, the respiratory membrane is spread over a plume-like surface and organ that juts out from the body, and waves about in water, which always contains air. In gills of many fishes, the mucous membrane is disposed in layers, between which the air-laden water is drawn; this is taken in at the mouth and ejected at the sides of the head. The tadpole, living its whole life in the water, breathes by gills; but the frog, into which the tadpole develops, has a more complex apparatus. The frog requires an apparatus for extracting oxygen from the *atmosphere;* the tadpole only had to extract it from the oxygenated water. As the tail of the tadpole shrinks, so also do the limbs develop; and at the same time, the new breathing apparatus develops. Its lungs, are sacs wholly surrounded by its trunk, and into it, at intervals, a sufficiency of air passes, is changed, and then expelled by the same tube-like entrance. This sac is lined with a delicate mucous membrane, and in its attached limiting surface, we find a network of capillaries in close contact. This is simple, yet the most complex respiratory organs, are constructed on the same principle; folding in and economizing space and area is a type of the higher lung, which is well illustrated by the simple frog lung, and its spaces, and central passageway of the incoming and outgoing gases.

FIG. 54. Lung of frog, cut open, showing its internal surface. (Dalton.)

Some small animals have no apparatus specially formed for external respiration; their skin, if moist, being all that is necessary. We may find no blood even in some of these low orders like the amoeba. The cell or cells taking up for

themselves such oxygen as is needed, but as the animal becomes more complex, these cells cannot perform all the proper functions, and hence we require more intricate and special organs for respiration. The higher the order of the species, the more complex the lungs.

The habits of Birds require that levity should be combined with strength in their confirmation. Had the lungs been constructed like those of quadrupeds and man, where the air is merely taken in and thrown out, a considerable addition of weight must have been the consequence. But by the very peculiar structure of the whole apparatus, which allows the air to be twice breathed, the lungs could be reduced to a very diminutive size, and still the aeration of the blood be as perfect as in man; and this is the admirable plan adopted in birds.

The Ostrich Lungs have bronchi similar to those found in man, which divide into numerous small branches after entering the lungs. They continue quite through the lung substance and open on the outside by many apertures. These are the true lung tissues of the bird, of course including the nerve and blood supply, and general anatomical structure. Their lungs are small and very thin, forming the dark substance always seen in carving a fowl, along the back and between the ribs.

These apertures admit the air into several larger air cells, which occupy a considerable proportion of the interior bulk. These cells enclose some of the principal viscera, as the liver, stomach and heart, and extend down the sides the whole length of the body as seen in Figure 54½. Numerous air cells also exist in other parts, with which these are connected by little punctures seen at C C.

LUNGS OF THE OSTRICH.

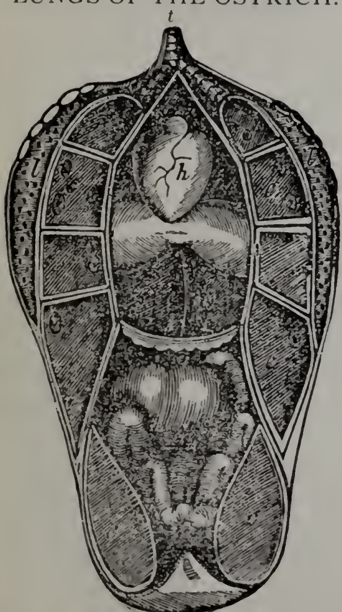

Fig. 54½—*t*, trachea and bronchi; *h*, heart; *l*, lungs; *c*, air cells.

The air vessels thus described, not only communicate with the interior of the bones, which, especially in the eagle and many birds that are frequently on the wing, are left hollow, and without marrow, for that purpose. In consequence of the large quantity of air consumed by the respiration of birds, the temperature of their bodies is several degrees higher than that of any other animal.

It may be this peculiarity of bird structure in the respiratory system, that has some relation to the capability we notice in them, of bearing with *impunity,* very quick and violent changes of atmospheric pressure. The Condor of the Andes has been known to descend rapidly 20,000 feet to the sea, when the air is three times the density of the high altitude, for this peculiar reason.

In certain insects, such as the *butterflies, bees, beetles,* etc., they have no lungs, specialized, but they do have *tubes* which ramify through the whole body, breaking up into extremely fine branches which ultimately reach the smallest point, even the individual tissue elements.

Lungs. In the human we have very complex structures for respiration called the *lungs.* However, a small amount of respiration is carried on in the alimentary canal. While eating food or swallowing saliva, air slips down, and gaseous exchanges take place with the blood of the gastric and intestinal mucous membranes So also, do we absorb oxygen through the skin, although it is dry, horny and non-vascular, superficially.

The *lungs,* then, are organs which help us to eliminate some of the waste products which have accumulated from the chemical changes in our nourishing system of circulation of the blood. One of these residual sybstances is CO_2. Wherever activity is, about the body, we find CO_2. Ordinarily we find it more especially in the blood, both in *arterial* and *venous;* but principally in the *venous* blood. The tissues of the body contain it, and it is removed at short intervals by the blood; also *moisture,* and a *fatty poisonous material* more poisonous than CO_2 comes from the lungs as waste products of the body. These we will consider later.

We take in oxygen by the same apparatus, and give it to the blood for distribution to the tissues. Thus our body

tissues must have O, and must get clear of CO_2. Hence the necessity of respiration.

Respiration, in short, means the function of the diffusion of gases, specially CO_2 and O. For this purpose, we need a thin, delicate membrane, with an inequality of gases on each side of it. The higher the animal, the more complex the organs, called lungs, must be. Man's lungs, cover more surface for the diffusion of gases than any other known animal; meaning, of course, when in health.

Our air passages are continuously open from the openings of the anterior nares, which are held thus, by cartilages and bone, especially arranged, and guarded by vibrissæ or hairs, and lined by mucous membrane peculiar to itself. This is called Schneiderian membrane, which is flat celled like the skin around the *entrance;* columnar celled in the *roof* of the nose, where we have the sense of smell well defined; and columnar ciliated in the *lower third,* and very erectile and vascular, secreting freely and acting as a sort of small furnace or heater, to take the chill from the air as it enters, going toward the lungs, and also to check the entrance of foreign particles, dust, bugs, insects and numerous foreign enemies to the lungs. We have highly developed in the hog, horse, dog, sheep, etc., a peculiarly twisted set of bones called tuberated, which serve as *heaters* of the cavity, and at the same time check the entrance of spiders, bugs, etc., which they necessarily would get from the grazing and eating particles of grass and grains on the ground.

The nose has a partition in the centre—partly bony and partly cartilagenous, dividing the nose cavity into two lateral fossæ. These fossæ are high, being narrowest in the middle, and also from before backward they are narrowest in the middle. Numerous cell cavities from hollowed and spongy bones about the head and face empty into the nasal fossae, all of which are lined with mucous membrane and filled with *air;* hence our large flow of fluids from the nose when a "cold" attacks us. The eye-secretions also empty into the lower part of the nose; so in overjoy or grief, the surface eye secretion pours into the nose, and we have to frequently use the handkerchief. Some one has said that the nose was a

dumping ground for all bad odors, flying particles in the air, and irritant secretions from the bone sinuses. Its functions are dual, for *respiration* and *smell.*

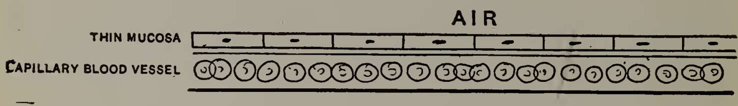

FIG. 55.—Diagram of the essentials of a respiratory apparatus. (F. H. G.)

Air entering the nose or mouth (it should always be through the nose), passes on to the pharynx, which is partly a digestive bag and partly a respiratory organ. Then to the larynx, or voice box, through an opening made for the purpose.

The Larynx is then the voice box, and also it is an opening for the transmission of the respired air, going into and coming out of the lungs proper. It is found in the anterior median line of the neck, between the hyoid bone, which is under the tongue, and the trachea with which it is intimately connected from below. It is triangular in shape, from two directions, above-downward and from behind-forward. The bases being above and behind, and the apeces being below and in front, respectively. The apex in front forming the *pomum Adami,* or Adam's apple.

It is made of three single cartilages—thyroid, crycoid and epiglottis—the shield-shaped, seal-ring, and leaf-shaped cartilages; and three pairs of cartilages, two arytaenoids, pitcher-shaped; two cuneiform, wedge-shaped, and two cornicula larynges, or nodules on top of the arytaenoids. These cartilages are connected by numerous ligaments, which form joints; and they are moved for different voice formations by numerous small and peculiarly shaped muscles. The interior is triangular above and circular below, and is completely lined with columnar epithelium, most of which are *ciliated* for the purpose of sweeping out the cinders and dust or mucous which happens to reach its delicate membrane. In this box we find the true and false vocal, or voice cords. These produce voice. Dr. Miles calls the larynx a music box.

The *Blood* supply comes from the superior and inferior thyroid arteries. *Nerves,* from the superior, and inferior or recurrent, laryngeal.

The Trachea is a membrano-cartilagenous tube, made of incomplete or horse-shoe rings of cartilages, 12 to 18 in number; and the openings of these incomplete cartilages, are filled in behind by elastic and fibrous membrane, mixed with muscular membrane. So the front and sides are cartilagenous; the posterior aspect is soft, because the gullet or oesophagus is in close proximity to this part of the trachea, and food passing down, requires no bony rings near, or the bolus of food would impinge upon them and cause choking. Hence the soft part of the trachea is behind, so that the gullet may have free and easy movement with its food products. The trachea is, as all air passages, kept continuously open, by these cartilages, and their power of elasticity, which also allows under certain circumstanges a slight variation in the size of its tube. The trachea extends from the larynx down to a point where it bifurcates into two shorter and smaller tubes, viz: *bronchi.*

Bronchus. The trachea then ends in a forked fashion, which we call the two, right and left bronchi. The right is shorter than the left and more on a horizontal plane. It has about the same structure as the trachea, being soft and flattened behind and made of cartilagenous rings laterally and in front. The left bronchus dips down and passes under the arch of the aorta and thus it is longer and more perpendicular than the right, and also has two or three more cartilages than the right.

The last cartilage of the trachea is peculiarly arranged, so that the ridge between the two beginning bronchi, allows a foreign body, like the seeds, buttons, pennies, etc., which children play with in their mouths, and frequently inadvertently take a deep breath and suck the body into one of the bronchi, usually, therefore, the right, from its anatomical arrangement.

Each bronchus divides up into smaller and smaller branches, called the bronchial tubes or bronchioles, within the lung on its own side; and these smallest bronchial tubes end

in saculated dilations, the *alveoli* of the lungs; these sac-like pouches being the air cells. Cell here, meaning cavity, in its simple form, not meaning that later technical morphological factor of the body, with a nucleus and nucleolus. The

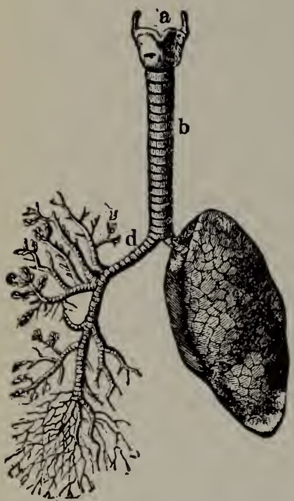

FIG. 56.—The lungs and air-passages seen from the front. On the left of the figure the pulmonary tissue has been dissected away to show the ramifications of the bronchial tubes. *a*, larynx; *b*. trachea; *d*, right bronchus. The left bronchus is seen entering the *root* of its lung.

FIG. 57.—Two alveoli of the lung highly magnified. *b*, *b*, the *air-cells*, or hollow protrusions of the alveolus, opening into its central cavity; *c*, terminal branches of a bronchial tube.

walls of these cells are especially rendered important because of the capillary network of vessels ramifying all about them.

These bronchioles lose their cartilagenous rings, when they become about 1-25 of an inch in diameter, and then become more muscular.

The mucous membrane of the trachea, and bronchial tubes are covered over by columnar ciliated epithelium. These move continuously, like grass or wheat, in one direction—upward toward the larynx, thus the mucus and substances from the lungs are brought to the mouth and throat.

They do better work while we sleep, and therefore, often we give *anodynes* to patients to assist them to bring up with these little hair-like sweepers all the irritants of the lungs.

The Structure of the Human Lungs. They consist of the bronchial tubes and their terminal dilatations; a large amount of connective tissues, which are soft, elastic, and sponge-like, and which allow the blood vessels, nerves and lymphatics to ramify and perform their functions. This is the perenchyma of the lung, or the binding together tissue, of all the lung structures. Under pressure of the finger, it crepitates or crackles; floats when thrown on water; being due to the air in the cells of the lungs. If the child has never breathed, the lung tissue will sink, because there are no air cells half inflated with air to buoy it up. To facilitate the movements necessary to these organs, each of them is provided with a double covering of an exceedingly smooth and delicate membrane, which we call the *pleura*. One layer of the pleura spreads over the lung-walls and the other over the chest walls, and with the utmost freedom they glide one upon the other. Like the heart membrane, the pericardium, it secretes a fluid of its own to lubricate at all times its surfaces, thus keeping them moist.

In the lungs the bronchial tubes ramify in a tree-like manner, and they resemble the trachea in structure except that the cartilage rings are not regularly arranged so as to have their open parts all turned one way. As the tubes get smaller, their structure also becomes thinner; the cartilages become less frequent and usually disappear just before reaching the air cell or sac, which is about 1-400 inch in diameter; the epithelium is reduced to a single layer of cells, which, though still ciliated, are greatly shortened when compared to those found in the large bronchial tube. The terminal air cells, or alveoli, have walls principally composed of elastic tissue and lined with a single layer of flat, non-ciliated epithelium, and immediately beneath which is a network of close capillary blood vessels. Thus air entering the lung is only separated from the blood by the thin capillary

walls and the epithelium, which is also thin. Both of these are moist and well fitted for gaseous diffusion, without irritation. These structures then comprise the lung substance.

There are two lungs, situated in and protected by the thorax, which is conical shaped with the apex up and the base down, closed in laterally by the ribs, cartilages and intercostal muscles. The sternum, cartilages and spine being anterior and posterior.

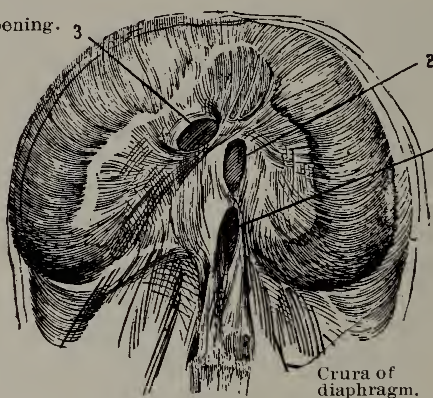

FIG. 57½.—The diaphragm seen from below.

The diaphragm, a musculo-membraneous structure, closes in the base, being higher on the right than on the left side, the liver on the right pressing it up. The middle of the diaphragm is tendinous, on which rests the heart muscle; the two leaflets, right and left, are muscular, and these are the parts which move up and down like a piston when we breathe; they go down when we inspire, and move upward when we expire or exhale the air from the lungs. It separates too, the thoracic from the abdominal cavities, being convex above and concave below. The diaphragm is attached to the ribs, vertebrae and lower part of the sternum, and has openings in it for the passage of the aorta, oesophagus, interior vena cava and some nerves, veins and the thoracic duct.

The blood and nerve supply come from the phrenic, respectively.

The ribs, especially the middle six, are peculiarly curved on themselves so that in inspiration the thorax is enlarged laterally, antero-posteriorly, and slightly from above downward. Thus, the ribs' action with the upward and downward motion of the diaphragm greatly enlarges their space for expansion and contraction, through their elasticity.

There are two lungs placed in this thorax, the right and left. Both weigh 42 ounces; the right, which has 3 lobes, weighs 22 ounces; the left only has two lobes, and weighs 20 ounces. The heart pointing toward the left, occupies the space which lacks the middle lobe; sp. gr. .745 to .380°; being lighter than water, as it is 1,000 sp. gr.; hence it floats on water.

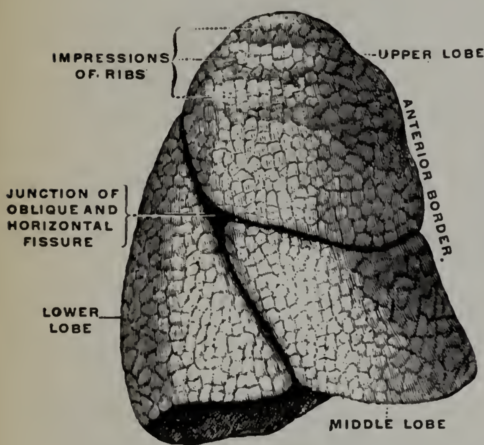

FIG. 58.—Right lung, outer surface. (Testus.)

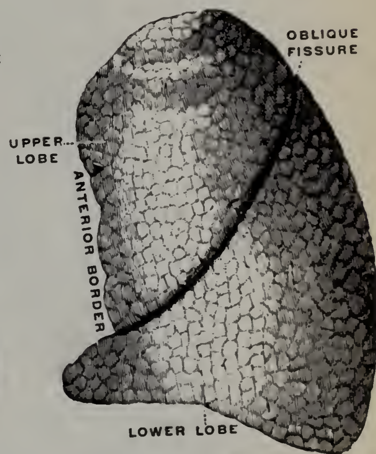

FIG. 59.—Left lung, outer surface. (Testus.)

The lungs are cone-shaped, with the apex projecting up, about ½ an inch above the clavicle; and the base is concave and rests upon the diaphragm. The external surface is convex, the internal, concave; the anterior border sharpened, the posterior blunt and convex. The root of the lung is made up of bronchi, lymphatics, bronchial artery, and veins; pulmonary artery and veins, and all held together by the pleura.

The blood supply for the nourishment of the lungs is from the bronchial; but the pulmonary arteries take the blood, which has come from the superior and inferior cavae

and the heart veins, through the lung for *aeration;* or to get more O and give up CO_2. This last is the real function of the lungs.

The nerve supply comes from the pneumogastric and the sympathetics.

Respiration is properly divided into two classes, external and internal.

External respiration is subdivided into two movements called *inspiration* and *expiration.* One, inspiration, takes the air into the lungs; the other, expiration, pushes the air, which has been changed, out again. Respiration may, however, be carried on without motion perceptibly of the thorax; this is well seen in the man who has fainted, or who is in a trance, or who is under the water. The gases can, and do diffuse, then, while the thorax is fixed, or not moving.

Sighing, which is often heard, is an exaggerated form of respiration, due to an excess of CO_2 in our lungs or bodies generally.

Exercise increases oxygen, if we need it, by quickening the breathing and thus using more air. Anything which will increase or diminish the capacity of the thorax will cause inspiration and expiration.

Drowning cases are readily revived, if not too far gone, by making use of the elasticity of the thorax, in squeezing or pressing the thorax at stated intervals. Cases of anaesthetic narcosis, are also revived in the same manner; and in opium poisoning we use the same method of reviving the patient.

In ordinary breathing the diaphragm is the muscle brought in action in men and children; but in women, the ribs are used more frequently. Nature seems to have provided in this way for woman's stage of child-bearing, when she uses her abdominal muscles for that purpose almost completely. In men then, the ribs scarcely move in ordinary breathing; in women, the ribs move freely and very perceptibly.

The diaphragm in inspiration contracts, and in so doing, approaches more nearly a level surface, thus enlarging the capacity of the chest.

Laughing, sobbing and sneezing are caused by the irregular and sudden action of the diaphragm. "Long wind" or deep, strong breathing, comes from a systematic exercising of the respiratory apparatus, which includes the diaphragm specially; this is done by the oarsman, the mountaineer and

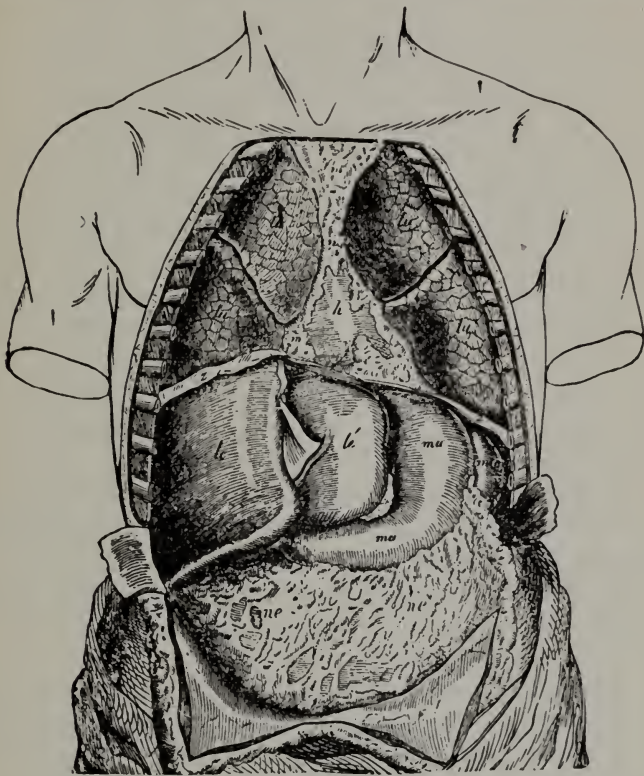

FIG. 60.—The Body opened from the front to show the contents of its ventral cavity. *lu*, lungs; *h*, heart, partly covered by other things; *le*, *le'*, right and left liver lobes respectively; *ma*, stomach; *ne*, the great omentum, a membrane containing fat which hangs down from the posterior border of the stomach and covers the intestines; *z*, the diaphragm.

the trained singer. Standing erect, shoulders back and taking deep inspirations develop the strength and capacity of the lungs and diaphragm.

Expiration is much less powerful than inspiration. The diaphragm relaxes, and ascends in the form of a dome; the ribs descend; the chest contracts, and the lungs themselves,

being highly elastic, contract and assist to thus drive out the air. These passages are used for both inspiration and expiration alike. At the close of the expiration, there is a short period of repose, which quite equals the period of action.

Muscles of Inspiration. When we inspire more than ordinarily, we use the ribs which are elevated by the external intercostals, thus making the chest diameters larger from above downward, laterally and antero-posteriorly. The diaphragm contracts and enlarges the vertical diameter considerably. In addition, we have in *forced* inspiration, the action of the scaleni, serratus magnus, quadratus lumborum, the pectoralis, major and minor, sterno-cleido-mastoid, and some say, the rhomboideus, major and minor. The muscles of the *nose* also help in forced inspiration.

Muscles of Expiration. They are the internal intercostals; and the great abdominal muscles; these, with the relieved force, from inspiration, relaxing; the elasticity of the lungs; also of the chest; and the muscular floor of the pelvis, assisting in trying to retain the normal and original shape; all these help expiration.

Coughing shows admirably the expiratory action of the abdominal muscles. They are the first muscles to get sore in chronic coughing spells.

The inspiratory muscles have to be stronger than the expiratory, because they have to overcome the elasticity of the chest walls and lung tissue.

The Respiratory Sounds are made by the entrance and exit of the air; these sounds, or murmurs, differ in character, over the trachea, bronchial tubes and alveoli. The science of *auscultation* of the lungs, is the art of detecting, by the physician, certain abnormal or diseased conditions of the lung tissues, etc.

There is evidently a pause in respiration, between taking in and forcing out the air, in quiet breathing. This pause, in diseased conditions, may be greatly prolonged. In sleep, the respiration is considerably slowed. In the healthy man, becomes, even in health, very irregular. In brain troubles, the respiration is considerably slowed. In the healthy man, respiratory movement is rhythmical and about 18 to 20 per

minute; or something like one to every four heart beats. Inspiration is shorter than expiration.

The hippopotamus breathes only once every minute.

The action of the heart somewhat influences the action of the lungs. For if the heart is quickened, a larger amount of blood is sent to the lungs and consequently they must act more rapidly, too. If the heart beats too fast and over burdens the lungs, we feel pain for the want of good wholesome air. We can hold the breath about 20 or 30 seconds; but if we expel all the impure air from the lungs first, we can hold the breath sometimes 1½ to 2 minutes. Practice may in-increase this wonderfully, and it at times saves many lives in burning buildings, by a knowledge of this fact. In India, the pearl divers can remain three or four minutes under water without being compelled to breathe. The will controls the respiration, yet ordinarily we breath unconsciously. Cut the nerves of the nostrils of a young horse and it will breathe itself almost to death from suffocation.

The Chayne and Stokes respiration means that the respiration gets slower and slower until it stops. Then it begins again, gradually getting faster and faster, till it reaches its height, then it again declines.

Apnoea is absence of the visible respiration. We can't see the movement, nor can we hear the respiratory action.

Heavy and deep breathing will sometimes cause temporary insensibility. In Paris they used to use this method with children for slight operations, such as opening abscesses, etc.

Dyspnoea means heavy breathing without any sign of disease in the lungs. It means Bright's disease usually.

Diseases and Irregularities of all descriptions influence respiration. All these, the physician recognizes the importance of and carefully records. The respiration in opium poisoning is characteristic, and important to the physician.

The Air We Breathe forms a vast oceanic, invisible, gaseous fluid, enveloping the earth, sea and all objects dead or alive upon the earth or sea. This is the atmosphere. It reaches 45 or 50 miles from the earth's surface, getting thinner as it ascends, and being thicker near the earth. This is the absolutely essential breathing air, which we breathe daily

and change in our lungs to suit the body requirements. We move and have our being at the bottom of this gaseous envelope; and even the fishes depend upon the atmospheric properties pervading the waters of the little river and great oceans, etc. Perfectly pure water will not support animal life; for if you extract the air from water, the fish drowns; and as easily as if the mouse had been held under water a few minutes. What is the cause? In both cases the animals have been deprived of their essential *air,* for breathing. Experiments prove that the plant, also dies, if the water supply be deprived of air.

This air which we breathe and move around in, cannot be seen. It presses upon us at the rate of 15 lbs. to the square inch, or about 80 or 100 tons in all, yet we feel it not. Is it not wonderful, then, that the tiny, flimsy, delicate, cobweb is left undisturbed? It is "softer than the softest down;" and "barely stirs the lightest flower that feeds on the dew it supplies; yet it bears the fleets of nations on its wings around the world, and crushes the most refractory substances beneath its weight." We feel it when in motion, as "wind." It stately forests; to elevate the waters of the ocean into ridges similar to mountains; and break huge stalwart ships into splinters. This air, deflects the sun's rays, and thus gives us the evening twilight and the morning dawn; thus, too, it refracts and disperses their various tints and beautifies the approach and retreat of the king of day. So this atmosphere, which at times may be dry, damp or changed to prisms and crystals, by the temperature changes, and the absorption powers, prevents the sunshine from bursting suddenly upon and dazzling our eyes, from darkness to bright noonday. But for the *air,* our evening twilight and softening beautifying landscapes, would be no more; the clouds which protect us from the scorching heat would be absent; nothing would be left but the barren earth, hot, dry and weak in earthly substances, revolving on its axis This air, then, is not, as the ancients supposed, a simple element, but it is made up of *two gases, Oxygen* and *Nitrogen,* in the proportion of about 1 pt. of O to 4 pints of N. They differ materially; being almost opposites, in properties. *Oxygen* is powerful,

active, incessant, and is the important element of the air, giving to it the power of supporting life and combustion.

Nitrogen is weak, inert and cannot support life or combustion. Lavoisier, a French chemist, discovered these facts in 1778.

The Capacity of the Lungs. The lungs are never entirely emptied of air, because the chest cavity never collapses completely. Nor, are the lungs either filled or emptied completely, by each respiration. In order to completely collapse the lungs, the pleural sac will have to be opened. Then all the air escapes and the lung collapses suddenly.

The chest or lung capacity in the ordinary adult of medium build is about 320-330 cubic inches, which is taken in (or expelled) by forcible respiration. This is in extreme inspiration, and after the most violent possible expiration. This air enters our lungs and passes out again by the nose, mouth, pharynx, larynx, trachea, bronchial tubes, bronchioles, thence to the air cells, and return. Most of the text books state that *fresh air* is taken into the air cells, but Dr. Miles holds that this cannot be, for the reason that there remains 100 cubic inches of air in the lungs, after a forcible expiration.

The Vital Capacity of the Lungs is about 220 to 230 *cubic inches*; this means the amount of air the lungs are capable of taking in and expelling, in a forced respiration. This is slightly varied in different individuals, and may be decreased by disease on nondevelopment, and correspondingly increased by exercise, singing, speaking, etc.

Tidal Air is the air we ordinarily breathe when at rest, using about 20 to 30 cubic inches, inhaling and exhaling; it comes and goes like the tidal waves.

Complemental Air is the amount of air which the lungs can take in when extreme effort is made in inspiration over and above tidal air; this is about 100 cubic inches.

Reserved Air, or supplemental, is the amount of air which we can expel by a violent expiratory effort; this is about 100 cubic inches.

Residual Air, about 100 cubic inches, is the last and deepest strata, so called, of the lung's contents. It is always

present, and cannot be expelled by the most violent effort. It remains, and it is in this residual air, that the important diffusion of gases takes place at the base of the lung.

Cardio-Pneumogastric Breathing is the expansion of the lungs to fill up what would otherwise be a space, when the heart contracts. This movement of the lungs sustains life in any one in a trance, so also in a faint. In this condition, the diffusion of gases takes place, but not so rapidly as in regular respiration. We only need an entrance and exit of air to have diffusion go on in the lungs. All materials, in order to get into the bottom of the lungs, must be gaseous; there, in the alveoli of the lungs, diffusion takes place; therefore, it is impossible to *inhale* anything into these small alveoli; air gets there only by *diffusion.*

Expired Air is changed somewhat in expiration. It is saturated with moisture and heated to the temperature of the body. It is also increased in volume 9% to 10%, but it is correspondingly decreased in weight, having given up a certain amount of N, which does not come out. Nitrogen gas is unchanged, but the other gases are changed in expiration. About 2160 parts of O is taken in, but only about 16 parts come out.

In inhalation, there is about .04 part of CO_2; in exhaled air, something like 4.38 parts CO_2. We find more CO_2 in the bottom of the alveoli than in expired air. CO_2 varies in quantity in health and disease. It is increased markedly during violent exercise, in menstruating women, and when eating certain forms of diet, especially cold foods. Cold increases CO_2 exhalation.

NH_3 is exhaled in small quantities from the lungs.

Crowd Poison is a fatty material which is exhaled, and which usually sticks to fancy trimmings, bric-a-brac, etc., in the room. It is more poisonous than CO_2, and is correspondingly dangerous. In a room with ½% to 1% of CO_2 people will not experience much inconvenience, but with less than that they become sick, due to the presence of this crowd poison.

Diffusion of gases goes on continuously, down in the alveoli, but we need a chemical change to further assist the

vital parts of the body. This is done in the alveoli, where the O is taken up by the haemoglobin of the blood, which is only separated from the air by a thin layer of semi-fluid capillary cell wall and epithelium of the lining alveoli. The haemoglobin of the red corpuscles has an intense affinity for O; therefore, we can well understand that all the O can be and is used up in a closed chamber, while N and CO_2 are left behind. O is loosely combined with haemoglobin, and it will easily give it up when put in a vacuum, and it will not take up more oxygen, if in an atmosphere of O, than if only there is enough to barely supply it. Why is this? Because the haemoglobin is very nearly saturated with O, always. It contains about 20-22% by volume of O, in arterial blood, and venous only contains 8 to 12%. Much less comes out combined with C in the form of CO_2 than is taken in. That which remains behind is called the respiratory quotient. How is this caused? By the O being partly used up by the body tissues.

We find more CO_2 in the venous blood than there is in the alveoli; hence CO_2 passes more readily out into the alveoli; and as we also have more CO_2 in the alveoli than there is in the outside air, hence it seeks to get out or diffuse quickly, and pass on out of the lungs by expiration. The plasma of the blood holds the CO_2 in some chemical manner, unknown to us. It is not found in the corpuscles, nor is it in solution. Some say that it is in the carbonate and bicarbonate of sodium loosely combined, so that it may more easily be given up.

This process of going in and coming out of the gases, cannot be fully explained by chemical changes alone. The *vital act* of the living cell-membrane lining the alveoli may be the explanation of these important changes, yet it is not conclusively proved.

The *blood* as it passes through the lungs does so through the pulmonary system; it is not heated in this passage, but may be even cooled. Its volume is slightly lessened, becaused it gives up moisture. The blood is not supposed to give up its waste or end products specially in the lungs; it is supposed to do this and thus become purified *in the liver and*

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the kidneys. On reaching the lungs, blood is a dark color, due to *reduced* haemoglobin; when it leaves the lungs, it is a bright red, due to oxy-haemoglobin.

Two things are effected then, by respiration—taking in *new* material and getting rid of *effete* matter. A tall man, up to 6 feet in height, increases his vital capacity for these important changes of gas diffusion; but higher than that shows no marked increase of change. Lifting heavy weights lessens, by straining the muscles, the capacity of the lungs; so also, firing large furnaces.

	O.		Co2.		N.	Water vapor.	Volume.
Inhaled air =	20.81	—	.04	—	79.15	variable	variable
Exhaled air =	16.03	—	4.38	—	79.30	satura'td	diminish'd $\frac{2}{3}$%

Internal Respiration, means the interchange of gases of the blood with those of the tissues; or the passage of the Oxygenated blood to the tissues, where it finds an excess of CO2; that is, more than is found in the blood; and a lessened amount of O than is contained in the blood. Hence another exchange of gases takes place. The blood gives up O to the tissues; the tissues give back CO2 to the blood. This is internal respiration.

Oxygen is liberated and given to the part which requires it. CO2 is returned to the blood, and passes on to the lungs to be re-oxygenated or exhaled.

CO2 is a very heavy gas, and will sink to the bottom of a vessel, and can also be poured from a bottle. CO2 is the result of slow chemical combination. It is poured forth from volcanic eruptions in enormous quantities. Being thus heavier than air, CO2 sometimes settles in caves, valleys and different fissures in the earth's surface.

In the Island of Java there is a place called the "Valley of Poison," the ground of which is covered with the bones of birds, tigers, and many wild animals; having been suffocated by CO2 fumes, while passing over it.

Lake Avernus, the fabled entrance to the infernal region, was, as its name implies, birdless, because the birds while flying over it were poisoned by this gas and fell dead into its waters.

Down in the mines, CO_2 forms the dreaded *choke damp*, and carbonated hydrogen is the *fire-damp*.

During repose a man exhales about ½ to 1 cubic foot of CO_2 per hour. One gas burner liberates 5 cubic feet per hour, or rendering impure, about as much air as 10 men in a room. A grate fire or a stove also damages the breathing air about as much as 10 men per hour.

CO_2 in small quantities causes headache, labored breathing, palpitation, and if continued some time, unconsciousness and even convulsions. In crowded lectures, jury trials in court, schools, etc., it may cause dullness, drowsiness and faintness, because the dark, impure blood circulates through the brain and oppresses it, thus causing it to act like a blunt tool.

What prevents our *death* from the falling of this heavy gas, CO_2? The wind, the cleansing rains, and most important of all, the readily *diffusibility* of the gas.

Consumption is caused by bad air. Place them in the open air in tents, is the best treatment, with good nourishing foods as adjuncts. The English barracks were first built without regard to ventilation. In those days large numbers died of consumption. Later, they built with better air ventilation, and most of the mortality report was thereby curtailed; so few died of any disease.

Consumption is lung-starvation. In the Zoo of Paris, most of the monkeys suffered with consumption till fresh air sufficient was brought into their cages; then the dreaded and fatal disease disappeared almost entirely. The best authorities claim that fresh air has more to do with stamping out this consumption scourge than all else combined. Good air, even influences good morals; bad air breeds ill-tempers and low averages of intellect and citizenship.

Gibraltar, Jamaica and Bermuda have the best climates, probably in the world; yet army life has been especially fatal there, because of close barracks, and therefore want of fresh air, free from saturated CO_2.

If blood rushes quickly through a part, it does not give up the oxygen to that part; hence if rushed through the submaxillary gland, it is found, on emerging on the other side.

to be bright scarlet red. CO_2 is formed by a slow combination of O of the blood and the C of the tissues. This CO_2 does not readily leave the tissues, but oxygen very readily leaves haemoglobin, if we exhaust the air from the receiver of an air pump which contains blood.

Absorption in the lungs is remarkable rapid, owing to the easy contact of the air with the blood vessel-capillaries, and also the large amount of lymph.

Respiration quickens circulation by assisting to act as a vacuum producer in the thorax, when inhaling or inspiring. As the lungs fill, the other vessels, respectively, fill and empty accordingly. The quickened breathing indicates an accelerated pulse and heart beat.

The color of blood has been proved by experiments with the spectroscope to be due to changes in the corpuscles; and according as they retain or release oxygen they present the spectrum of arterial or of venous blood.

Color—Arterial blood, scarlet, O, 21.6%; CO_2, 40.3; *venous blood,* dark blue-red, O, 8.12%; CO_2, 45.46.

Water is greater in amount in venous and less in arterial blood. Arterial is warmer than venous blood. O, is the food of the blood corpuscles; and our daily meals and drink, of plasma.

Hunger means a demand of the system for good food; so also *suffocation means* a demand on the system for more oxygenated air.

Blue blood, long ago thought to only flow through the blood vessels of the royal veins of kings and princes, was usually boastfully spoken of. Now, however, we know blue blood to be bad blood, which indicates waste and decay.

Air, once breathed, is no longer fit for respiration. Place an animal in a closed space and compel it to breath its own exhaled air and it soon dies; and if, then, you place a lighted candle in the compartment it is quickly extinguished.

The moisture in expired air is noticed if you breathe against a mirror or window pane, which becomes tarnished by the condensation of watery vapor given off by the lungs. The cloud seen emanating from the nostrils in cold weather, shows the same presence of moisture in exhaled air.

The animal matter of exhaled air, if kept, speedily putrifies and becomes highly offensive. This is considered more poisonous than CO_2 in crowded spaces. *History* is full of painful instances of the ill-effects of overcrowding. In 1756 only 23 of the 146 Englishmen imprisoned in the Black Hole of Calcutta lived through the 8 hours. There was a mighty rush for the one small window, and it was only the survival of the strongest who lived through that dreadful 8 hours, rebreathing each other's foul air, and animal exhaled matter. On board a ship during a stormy night, 150 passengers were confined in a small cabin; when morning came only 80 were alive. Three hundred prisoners were crowded into a cave after some great battle, and in four hours two-thirds of them died for want of fresh air.

Breathe pure, fresh air, and ordinarily you will grow up, strong, large, ruddy, cheerful, active and clear-headed. Breathe bad, foul air, and you will grow up, small, weak, pale, nervous depressed, unfit for work, and usually tempted to resort to stimulants, and eventually become drunkards. A mouse, if placed in a box and you breathe through a tube into it, soon faints, and if you continue to do this, it dies.

What becomes of this expired air which leaves your lips? It feeds plant life, flowers, and palms. They take in CO_2 and nourish their tissues with it, and exhale through their leaves, oxygen. Thus, *our* waste, feeds and builds their tissue up; and vice versa, *their* waste, nourishes our tissues with O.

The number of respirations in a minute is about 18 to 20. In the baby about 30 to 40 per minute. The hippopotamus breathes only once every minute. We use about 10 pints of air each minute or something like 60 barrels daily, through our lungs. We have 5% absorbed in its transit through the lungs. In one full breath, we are supposed to exert a muscular force equal to raising 200 lbs. placed upon the chest.

Impure Air is deficient in oxygen. Some, if inhaled, proves fatal; *arseniuretted hydrogen* being one of these, a single bubble of which destroyed the life of the discoverer, Gehlen. Bad gases have a bad odor, hence our sense of smell

warns us and often acts as a safeguard. This is why nature placed this special sense at the very entrance of the air passages. Never breathe the breath of the sick, for they expire considerable quantities of diseased poisonous principals which you may contract. Be clean, is the best rule. Water and a good brush, well used, are better than disinfectants. In England, "Preventive Medicine" was first tried. Cleanliness was the dictated rule; and it reduced the epidemic mortality enormously.

Dust in the air can be seen as the haze that makes the ray of sunshine across a darkened room. In the same manner we have found numerous animalcules in the water we drink. Both the dust particles and drops of water contain the germs of disease in many cases, which may account for our different attacks of various complaints. Cotton wool is the best filter for bad air; it should be kept in case of fire, and then used to escape through the smoky hallways, etc. A handkerchief is also good; and these should be used in a sick room, too. Dust, strong sunlight, irritating air, etc., cause sneezing and coughing, which differ only in the latter's passing through the mouth and the former through the nose. Hiccough is only a backward cough, and often it causes great exhaustion by continuing for days and even months. Sighing and groaning may be the signals of the lung tissues for better and fresher air. Or in children, it is a means of full inflation and development of the lungs. Most of these irregular respiratory movements are performed by the diaphragm principally.

Artificial Respiration is effected by pressing at regular intervals upon the thorax and relaxing, then repeating each about 20 times a minute. To facilitate this valuable mechanism, always extend the neck, mouth open, tongue depressed and drawn forward. Sufficient fresh air, too, is necessary; and the application of the faradic current of electricity.

What is the excitant cause of normal respiration? It is *absence of sufficient oxygen;* not the presence of CO_2. If you cause displacement of CO_2, by diffusion of some other gas than O, you will have dyspnoea. In pregnancy the large amount of O furnished by the placenta is sufficient to keep the respiratory center quiet. It does not need O, and hence

is not excited. When the child is born, the supply of placental O is cut off, and immediately its center is excited by this want of O, and the child breathes or cries; this means a deep respiration. Hysterical people often hold their breath indefinitely; place your fingers over their nostrils and (mouth covered) you will soon notice that they begin to breathe normally. Rhythmical respiration is kept up continuously through the influence of the nervous system. There is supposed to be a respiratory center in the optic thalimus. Some say respiration consists of three acts—inspiration, relaxation and inspiration. These centres can be inhibited, especially, by the Glosso-pharyngeal nerve.

Is the want of O the only cause of respiration? No. The center may be excited reflexly. It is one of the most easily excited centers, found in the floor of the fourth ventricle of the medulla. Heat, cold, dash of cold water, emotion, anger, irritation of organs by disease, sight, sound and numerous others, cause an increase of the rhythm of respiration. If a patient knows that you are counting the respiration, it is apt to increase. The self-adjusting theory is, that inspiration excites expiration and vice versa. *These centers,* two on each side of the median line of the fourth ventricle, are influenced by the pneumogastric nerves, and if one is cut you have slower respiration on that side. If both are cut, general respiration on both sides is slowed and deepened. These centers are subdivided into two, one for inspiration, the other for expiration. Irritation of the pneumogastric and many others, deepens inspiration; irritation of the superior laryngeal will cause expiration, and if continued, will cause spasm of the muscle in expiration. If compelled to go through smoke, close the nose and breathe through the mouth, thus preventing expiratory nerve irritation, and coughing, etc.

Blood goes to the lungs by two sets of vessels. The *bronchial* arteries, branches of the thoracic aorta, supplies the bronchi, bronchioles, infundibular and alveoli with nourishment. They do not even anastomose freely with the other set, or pulmonary system of vessels. They are solely for nourishment of these tissues.

The pulmonary circulation is carried on by the pulmonary arteries taking *venous* blood from the right ventricle,

and breaking up into smaller vessels running beside the bronchial tubes, (but not supplying them), which in turn divide into capillaries at the air cells or alveoli. They do not remain on the outside of these air cells, but run along in the walls of the cells and even inside them, like vines growing on a trellis. Thus, the *air* and the *blood* are *only separated* by the capillary walls of the vessels, in a great part of their course. This blood is taken to the lungs, then, only for oxygenation or chemical changes, and does *not supply* or *nourish* the lung tissue at all. It is then collected by the four pulmonary veins (now being arterial blood) and brought to the left auricle, and thence to the left ventricle, from which it is propelled all over the system. This is termed the *pulmonary* circulation; and the latter from the left ventricle, the *systemic* circulation.

Ventilation. Why do we ventilate? To get rid of the CO2? No. CO2 can, with other gases, escape through the cracks in the walls, and chinks around the windows and doors. But we want to get rid of that unknown *organic matter* which is so dangerous, and which clings to everything in the house, like curtains, carpets, rugs, bric-a-brac, etc. It accounts for some of the bad breaths we find in people who have perfectly sound teeth. Florence Nightingale tells us "to leave the window open at night, it cannot injure the voice." It is, we found, a purifier, disinfectant and strengthener. Benjamin Franklin said, "Health is wealth."

Animal Heat really belongs to the respiratory system, as it has to do with our combustion by oxydation processes. It is produced by chemical changes in our bodies, which are produced by muscular exercise, friction, and metabolism of the tissues generally The nervous system controls the heat or temperature of our bodies. Our body temperature is about 98.2-5, and remains the same winter and summer, in the tropics, or in the frozen regions of the north. It may change temporarily, but any long-continued elevation or diminution of the body heat will usually result disastrously. Man is able by means of clothing, shelter and food, to adapt himself to all extremes of climate. The power to resist cold consists chiefly in preventing loss of heat by radiation. *Perspiration* and *evaporation* with the *nervous system* as *chief* regulator,

influence and keep the temperature of the body normal. Evaporation produces cold, and this fact has been ingeniously and practically employed in the manufacture of ice by means of freezing machines. Try your own hand by applying ether or some volatile liquid and then fanning the part. It quickly becomes cooled.

Birds are *warmer* than the *air,* and the fishes than the water, into which they both live. Plants, also generate heat, especially when sprouting and flowering. Place a thermometer in a cluster of geranium flowers, and it will show a temperature several degrees higher than the surrounding air. The degree of heat is always proportional to the activity of respiration and the amount of oxygen consumed. Therefore, the birds, being most always active, have the highest temperatures. Frogs, lizards, snakes and all sluggish animals have little need of oxygen, because they are not active, and hence their lungs are incomplete and simple in structure. Zoologists have arranged the animal kingdom into two classes, the *warm-blooded*, including man, birds and quadrupeds; and into the *cold-blooded,* which includes the fishes, frogs, tortoise and all that class of animals. Those with no vertebral column are classed by themselves.

Thermogenesis is the power of the nervous system which governs the production of heat; and *thermolysis* controls the dispersion of heat.

Thermotaxis means those two combined, to regulate the body heat.

Alcohol is injurious to the respiratory centers. Shortly after drinking wine or whisky the breath indicates its presence in the lung tissue. From the stomach and intestines it readily gets into the blood current and is taken to the lungs as well as to many other parts of the body. This means by the increased respiratory movements that an unnatural labor has been placed upon the lungs to help get rid of this drink; hence, less oxygen is taken in and less CO_2 is given out, and naturally we are not so strong for this reason. In habitual drinkers, we notice a hoarse voice and wheezy breathing, and by this usually accompanying exposture, easily fall a prey to all kinds of chest diseases, and early death.

CHAPTER XV.

THE URINARY SYSTEM.

The Kidneys, Bladder and Skin.

The respiratory and alimentary systems have both the double function of appropriation and elimination of materials to and from the tissues, both supplying new material and taking away waste. But the urinary system is purely excretory in character. It gets rid of the *nitrogenous waste* materials of the body, which if allowed to remain, would injure the organism and ultimately destroy life.

The organs which form this important function are the (1) two *kidneys,* the glands which secrete the urine, (2) the *ureters* or tubes of the kidneys, which convey their secretion to the (3) *urinary bladder,* a reservoir for the retention of the urine and from which it is expelled from time to time as nature dictates, through (4) an exit tube, the urethra. The anatomical arrangement can be seen in the figure below.

From the bladder the urethra extends in the male about 7 inches to the exterior, and about two inches in the female.

The ureters, two in number and about 12 to 18 inches in length, pass from the Kidneys downward and enter the bladder walls very obliquely. Therefore, if the pressure inside the bladder rises above that of the liquid in the ureter, the walls of the oblique passage are pressed together and consequently are closed.

The bladder is usually relaxed and the urine flows readily from the ureters into it. This dilated bag or reservoir holds about ½ to 1 pint; if more is found in it, discomfort increases proportionately. The bladder is formed of a thick three-layer-muscular tissue, and lined with a mucous membrane, covered with peculiarly irregular cells, called *transitional* cells. The beginning of the urethra is kept closed by very elastic tissue around it, which may be reinforced by muscular fibres, voluntary in character, which compress the urethra. When the bladder contracts and presses on its contents, the ureters above, being closed as above stated, and the

elastic fibres of the urethral exit from the bladder are overcome, then the urine, liquid in form, is forced out through the urethra.

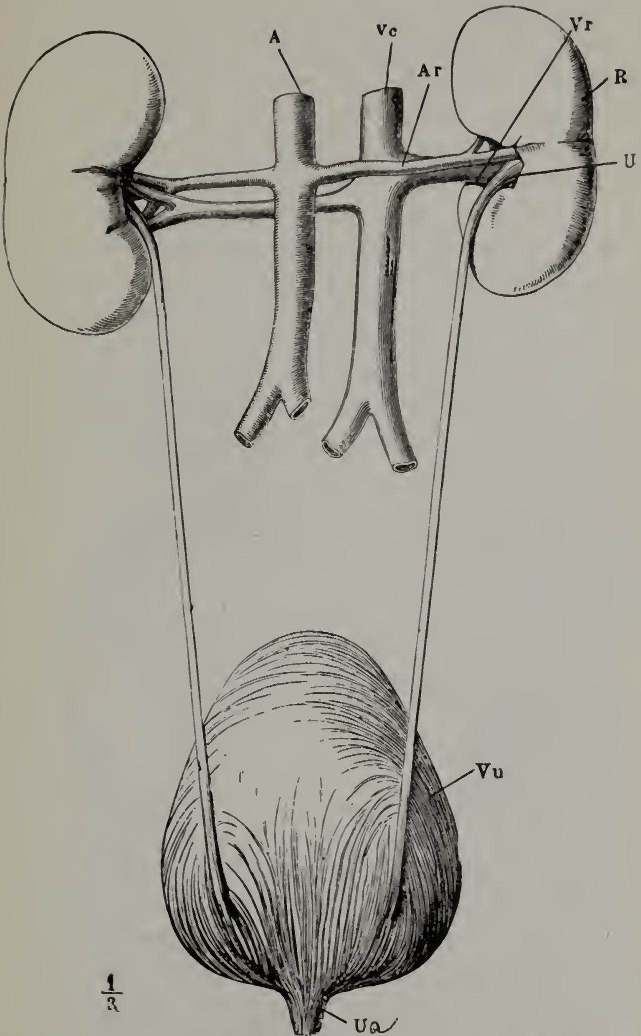

FIG. 61.—The renal organs, viewed from behind. *R*, right kidney; *A*, aorta; *Ar*, right renal artery; *Vc*, inferior vena cava; *Vr*, right renal vein; *U*, right ureter; *Vu*, bladder; *Ua*, commencement of urethra.

The *blood* supplying the bladder comes from the superior, middle and inferior vesicle arteries.

The *nerves* supplying it come from the 3d and 4th sacral and the hypogastric plexus of sympathetics.

The Kidneys. These are the most essential organs of the urinary system. They are two in number, located in the loins behind the peritoneum and the intestines, and are on each side of the spinal column, resting on the diaphragm and the quadratus and psoas muscles. They reach up to about the 11th rib and down to the 3d lumbar vertebra. In shape they resemble a bean, or as we call them, kidney-shaped. They are 5 inches long, 2 inches wide and 1½ inches thick; they usually weigh about 5 to 7 ounces. Externally, the kidneys are a red-brown color, which can be seen through the transparent *capsule* of peritoneum, which covers the anterior and lateral surfaces of the organ. It has an anterior and posterior surfaces, which are convex and flattened, respectively; superior and inferior extremities. The supra-renal capsule being on the superior extremity which is larger than the inferior; and external convex, and an internal concave border, the internal presenting a hylum for the entrance and exit of the renal arteries, and nerves; and the renal veins, lymphatics and beginning ureters. They rest in a bed of fatty tissue covering the muscles, and are nearer the posterior than the anterior abdominal wall.

Make a cross section through the kidney from the outer to the inner border and we notice a deep fissure, called the *hylum,* in the latter. This space is mostly occupied by the beginning funnel-shaped ureter, and, as before mentioned, the vessels, etc. This dilated part of the ureter is its *pelvis,* and it is made up of small cups or *calices,* which receive the many drops of urine delivered to them by the long delivery tubes found in the malpighian pyramids, later to be described, as the important part of the medullary portion of the kidney. We notice on section as above, that the kidney is composed of *two* distinct parts; an outer or *cortical* (or bark) portion, which is granular and red and less shiny than the *medullary* part and is near the periphery of the organ, although it dips down between the pyramids, thereby separating them; these are called the columns of *Bertini.* We find the microscope reveals other interesting factors to be described later.

The *medullary* (*or pith*) *portion* is less red and more glistening to the eye; it is striated, radiating like spokes in a wheel, and is made up of pyramids, called *malpigpian* pyramids, which are separated by the dipping down of the cortical substance between them. These pyramids become pointed, and empty into the beginning *cups* or calices of the *pelvis* of the ureter; these parts are called the *papillae* of the pyramids. Externally, each pyramid sends prolongations of their tubes up between the cortical portions, and we call these, which have their bases down toward the bases of the malpighian pyramids, *pyramids of Ferrein.* In early life the kidneys are composed of tiny lobules, which become indistinct or entirely absent to the naked eye in adult life. The structure of one of these small lobules is really the same as the structure of the whole kidney substance.

The Minute Structure of the Kidney, They are compound tubular glands, essentially composed of branched mi-

FIG. 62.—Minute Structure of Kidney.

FIG. 63.—Malpighian Body. (Magnified.)

nute *uriniferous tubules,* which tubules are lined with a peculiar transitional epithelium, composed of flat, square, oblong and very irregular cells. Each tubule begins at a papilla as a small dot, or opening in reality, and continues in a most tortuous and complex manner to end in a dilitation at its other extremity. About 20 of these tubules open, side by side, on one of these papilla. They have there a diameter of about 1-200 of an inch. From this point each tubule runs

into the pyramid and divides into several others. The branch tubes at first are smaller than the main tubes, but as soon as these diminish to about 1-600 of inch, they then cease to get smaller, and henceforth remain the same size. Thus the pyramid gets its conical or pyramidal form, not wholly, but partly. Then these branches run somewhere out of the pyramids, either from its base or sides, into the cortex and there dilates and is very much twisted. It then narrows and runs back again into the pyramid and descends toward the papilla as a straight tube, then makes a loop just before reaching the papilla and ascends toward the base of the pyramid again as a straight tube, where it once more enters the cortex, dilates and becomes tortuous and ultimately ends in a spherical capsule, which contains a tuft of small, but *not capillary*, vessels. The long loop made is called the *loop of Henle*, which has a descending and an ascending limb. The spherical capsule, where it terminates, is called the *capsule* of *Bowman* or Malpighii, which is the important part for extracting the *water and the salts* from the blood-vessel-tuft, which bends in all directions, but does not become capillary in character. This tuft is made by an *afferent artery*, and the vessel leaving the tuft, after having given up water and salts, is not a vein till after it goes to the proxymal convoluted tubule and gives up *urea, uric acid, kreatinine, acetone and hippuric acid*; then it leaves as a *vein*.

The Glomerulus, or tuft of vessels, does not always completely fill Bowman's capsule. It seems to vary according to pressure from the blood inside the vessels. Where do these vessels get their blood from? From the afferent vessel of the cortical arteries. From where do the convoluted tubes get their blood? From the capillaries of the efferent vessel. The blood that leaves these convoluted tubules then, is venous. The *Malpighian corpuscle* includes the glomerulus, or tuft of vessels, and the capsule of Bowman, with the entrance of the afferent and the exit of the efferent vessels. The glomerulus is arranged to delay the current of blood and allow the cells to act upon it, while slowly going through the convoluted tuft of small arteries. Epithelium covers these small vessels while in the capsule of Bowman. Where are the glomeruli found?

Only in the cortex. We have both *straight* and *convoluted* tubes in the cortex; but only *straight* tubes in the medullary part. All these numerous small tubes are lined by the peculiar transitional epithelium, which at some points, almost occludes the lumen of the tubule. Connective tissue binds these tubules together, and with the two, connective tissue and tubules, the whole structure of the kidney is formed. The cortex is the secreting portion of the kidney.

The blood supply of the Kidneys comes from the renal arteries. There is a peculiar division of the blood supply going to the organ; three-quarters of the blood goes by large branches to the *anterior* three-quarters of the kidney structure, and one-quarter of the blood goes by the smaller set of vessels to the *posterior* one-quarter of the organ. Between the two blood zones is a distant *non-vascular area.* It can in many cases be recognized by a slight groove; immediately behind the central line between the middle of the external border and posterior surface. It should be looked for, before operating on the kidney.

The renal vessels enter the hilum of the kidney and break up into branches called arteriae propriae renales which pass up between the columns of Bertini to the boundary zone, at the bases of the Malpighian pyramids; there, they form arches, called by some, vaginal branches, which communicate with each other. From these arches two sets of vessels are given off, a descending and an ascending set. The descending set, called the *vasa recta,* pass down into the malpighian pyramids, and have no part in the secretion of urine. The ascending set, called the *interlobular,* run up between the pyramids of Ferrein and give off branches, which go to the capsules of Bowmen, and form the tufts or glomeruli by their afferent and efferent vessels as before described. This capsule of Bowman epithelium has nothing to do with the secretion, but the reflected part of the capsule over the glomerulus cells *have* to do with extracting *water* and *inorganic salts* therefrom. Some of the cells dip down in to the glomerulus and are closely associated with it.

What nourishes the cortex or "bark" of the kidney? The branches which come from the efferent vessels from the

glomerulus. These vessels also form stellate or star-like arrangements of vessels which supply the extreme periphery of the cortex.

The veins correspond to the above named arteries, and eventually terminate into the renal veins which empty into the ascending vena cava at a right angle.

The Nerve Supply of the kidney is made up of the sympathetic system and pneumogastric branches forming the renal plexus.

The Renal Secretion is somewhat influenced by perspiration, which diminishes its flow, and by cold, which increases its flow. The average amount secreted in 24 hours is about 2 to 3 pints. In health and disease both, we have irregular secretions at certain periods. *Urine* is straw or

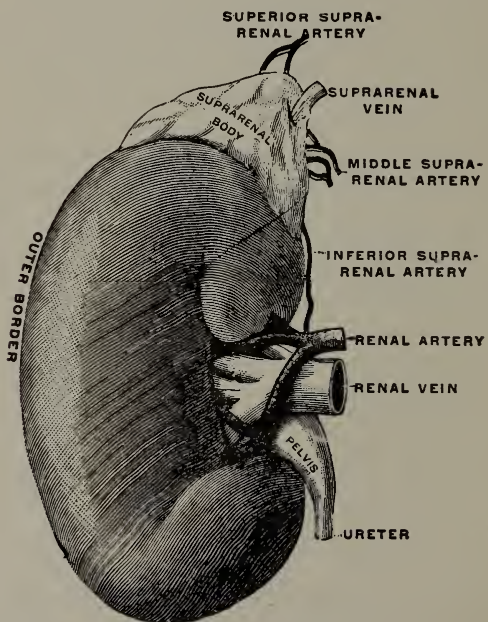

FIG. 64.—Right kidney, ventral aspect. (Testut.)

amber in color, due to the presence of normal *urobilin*. Its color varies in accordance with the presence or absence of this coloring agent, or also with the drugs or foods taken. Carbolic acid will cause it to turn black, bloody and very

thick. Asparagus turns it brown and rusty, with a very foul odor; other vegetables and drugs affect it. The sp. gr. of normal urine is from 1015 to 1025; if scant in secretion, the sp. gr. is raised; and vice versa. The odor to urine is characteristic. If allowed to be exposed to the air, urine will have a strong odor of ammonia. Turpentine will cause urine to smell like violets. In Diabetic urine, the odor is sweetish, like new-mown hay. To the taste, urine is a bitter-salty fluid. Reaction in humans is acid, due to the acid sodium phosphates. This, like the color, varies, but in 24 hours, it equals about two grammes of oxalic acid. The reaction of herbivorous animal's urine is alkline. If we eat a great deal of sugar, we will find sweet sugary urine. Under nervous influences, as anxiety, emotion, etc., urine secretion increases markedly.

Constituents of Urine. Of 1,000 parts of urine normally, 960 are watery and about 40 solids. *Urea* is the most abundant solid of urine. It is highly nitrogenous, and the *peasants* secrete about 12 grammes daily, to the 44 grammes by the diners at Delmonico's. It is always found in solution in the urine, and never as a deposit or crystal. The liver secretes most of the urea of the body. The chemist can manufacture it in his laboratory.

More urea is found in renal-artery blood than in renal-vein blood, which indicates that urea is not made in the kidneys. Death suppresses renal secretion, but, urea still accumulates in blood.

By evaporating the urine down to one-half and treating it with HNO_3, we get scales of urea nitrate. It is not poisonous; other poisonous compounds probably act and effect the urine, and body, in the so-called uraemic poisoning. Eating large amounts of nitrogenous foods will increase urea in the urine considerably. We find in small quantities, urea, all over the body. Exercise does not increase it. We found that the epithelium of the convoluted tubules secreted urea, and also make small quantities at the time of secretion.

Uric Acid also is secreted by the epithelium of the convoluted tubules, and is a nitrogenous substance, yet less highly organized than urea. About 10 grains is secreted

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daily, and is usually found in the urine as urates, sodium, etc. If in large quantities it will be deposited in the crystal state, shaped something like a whetstone or boat-shaped. Their color is a reddish brown. Muscular exercise increases the amount of uric acid. Uric acid is secreted in place of urea in *birds* in large quantities. Most any simple acid has the power of taking the Na or Mg from urates and precipitate uric acid.

Acetone has been found in urine.

Kreatinine is a nitrogenous substance formed by muscular activity, and is secreted daily in amounts equal to about 8 to 20 grains in 24 hours.

Hippuric Acid is only found in small quantities in human beings, but in the *horse* we find it in place of uric acid and in large quantities. Feed a horse on Benzoic Acid and the kidney will secrete hippuric acid, which proves that tubular epithelium has the power of making hippuric acid.

The other organic or nitrogenized compounds found in the urine are less important.

Inorganic Salts are found in the urine, as abundantly as we find them in blood, the juices, etc. The *Sodium Chloride* predominates, as elsewhere, being secreted in about 180 grains in 24 hours. It varies both in health and disease. In melancholia, the *potassium salts* exceed the Sodium Salts. *Phosphoric acid* was supposed to have been one of the constituents of urine. *Carbonates* of Na., Mg., etc., occur in the urine. If you increase the quantity of organic acids, the carbonates are correspondingly increased so that the urine may become alkaline in reaction; so also if you allow urine to stand in a bottle uncorked it will become alkaline due to the micrococci of urea breaking up the urea into NH_3 and the carbonates, which has then the odor of ammonia.. Many substances, it is interesting to note, are secreted by the kidneys unchanged comparatively; such are alcohol, iodine, bromine, etc. The story of the Russian nobleman and the peasants illustrates some of these facts experimentally.

Secretion of Urine. There are many theories concerning the secretion of urine. Some of them, we will briefly review.

Some say that the secretion of urine is in proportion to the amount of blood sent to the kidneys, and that the urine is only *filtered* from the blood. They claim that the *calibre* of the *efferent* vessel is less than that of the *afferent;* and thus the pressure of these thin walled vessels of the vascular glomerulus is raised enormously. Hence the secretion. *Dialysis* is the same as the above *filtration* theory.

Then, others agree to *filtration* for extracting the salts and water from the glomerulus, but think that there is a *special* activity of the cells of the epithelium for secreting the solids.

Dr. Miles, disproves this theory, by saying that if this were true, we would have an increase of urine whenever the blood was increased to the kidney. This is not the case, however. For example, tie the afferent vessel of a glomerulus for a time and then remove the ligature. There is then an increased supply of blood going to the glomerulus, but instead of secreting an increased amount of urine, it has a decreased amount. We find the same thing in inflamed kidneys, when the kidney is filled with blood; the secretion is then also decreased.

Heidenheim injected indigo blue (Indicate of Soda) into the veins of animals, and after allowing it to pass out by the kidneys, through urine solution, he killed them and found the *cortical* substance stained *blue;* columnar epithelium lining the convoluted tubules were found especially to be thus stained, hence these convoluted tubules have to do with the secretion and elimination of the solids, which are principally urea, and uric acid

The glomerulus, undoubtedly secretes the fluids.

It is a *vital act* of the epithelial cells, influenced by the nervous system, which causes *urine secretion.* There is a point in the 4th ventricle—calamus scriptorium—which, if stimulated, secretes urine. The vaso-motor system regulates the calibre of the vessels in the kidney, and hence influences its function.

Albumen in the urine may be caused by a diseased area of epithelium. Ask if the patient has been sick with fevers, malaria, etc. Do not say at once, Bright's Disease, but care-

fully examine your case, first. Urea may be found in the urine from mere waste of the body tissue, which generates urea. You may have almost complete suppression of urine secretion, without any bad symptoms of so-called uremic poison. Urea does not poison; it acts more as a signal of poison elsewhere in the kidney or liver.

Tube casts are strongly refractive bodies which represent the nucleus of the cells lining the tubules, which have been exfoliated, from diseased conditions of the kidneys. If they take on carmin coloring quickly, and are highly refractive, mark it down a case of Bright's Disease. There are some fatal cases of Bright's Disease without the appearance of albumen. You may also have albumen, without tube casts, in Bright's Disease.

The tests for albumen, most commonly employed, are first boiling; nitric acid test and many others. By boiling or rather heating albumen (supposed to be in the urine) it will *cloud* just before coming to the boiling point. So always try this first. If it is a collection of phosphates on the top, by adding a few drops of nitric acid from a pippette will disperse and clear it up.

Put nitric acid in a test tube; then by pippette, drop a few drops of the suspected urine in the slightly inclined tube; you get, if albumen is present, a *dark* perfect ring of coagulum or *albumen.* This is a simple but a good test.

The test for sugar is usually Fehling's test. It is better to keep the two solutions, separate till needed, then add them. Boil the test solution before testing, then add the suspicious urine, and watch the yellow-gold color appear if sugar is present. Diabetic urine has been kept for years and still you can find sugar in it. Sugar is constantly found in small quantities in urine; and by eating sugar it increases this slight amount somewhat. After an attack of epilepsy you frequently find albumen in the urine. You can diagnose from apoplexy and drunkenness by this test sometimes. *Blood* in urine may be from bladder hemorrhage; or it may be caused by a *too drastic purge,* thereby rupturing the delicate blood vessels. *Eggs,* eaten promiscuously will cause albumen to get into the urine.

Urine is retained, according to Landois, by the very elastic urethral walls; man seems to have more need than woman for these elastic fibres. She being more able to retain her urine than man. All these functions are reflex in nature, and if by paralysis, we take this influence away, why the urine dribbles at all times just as it is secreted by the kidneys.

These different substances secreted by the kidneys are already in the blood which goes through the organ, and are picked out by the living protoplasm of the cells in the glomerulus and by those lining the convoluted tubules. It is the living cells that prevent the albumen from escaping. Sicken, or injure these cells, and albumen gets into the urine.

CHAPTER XVI.

THE SKIN OR INTEGUMENT.

The skin is the external covering of the body. The numerous nerve filiments immediately beneath the skin make that area especially sensitive, and we require some such covering as the skin to protect these highly sensitive parts from the external objects with which we come in daily contact. If the skin is torn off, even the pressure of the air is painful. Nature, then, has amply supplied this want of protection by placing about our entire beings a garment which is soft, pliable, thin, close-fitting, and acts as a continuous radiator of, or disseminator of heat; and protector from the cold. And it is sufficiently tough, to allow these many moving objects of our suroundings, to come in contact with us without inconvenience or pain.

It is the great organ of protection to our bodies; of sensations of heat, cold, pain and various others. It has rightfully been called the organ of reception and we thus get our impressions from it. By friction of the skin externally, we may affect some of our internal organs. It is from the delicate sensitiveness of the skin that we are able to make diagnoses of certain diseases and tumors. Some diseases deaden our sense of heat and cold. The skin too prevents absorption of certain poisonous materials, and helps at the same time to prevent evaporation of the water of the body. The skin then, is important.

Neglect to bathe, and regularly cleanse the skin, and as a consequence, the lungs and kidneys have to do more work to eliminate certain poisons, and perform other functions extra of their ordinary capacity. The skin should be clean and free.

Animals, a considerable portion of whose skin has been varnished, die in a few hours. This was once thought to be due to retaining ingredients of the sweat, which poisoned the system. The real cause, however, of the animals' death

seems to be an excessive radiation of heat from the body-surface, which the vital oxidative processes cannot equal, therefore, the body-temperature falls until it reaches a fatal point, which in the rabbit is about 68°F. Pack such an animal and keep in raw cotton, or in any temperature above 86°F., and it will not die from the varnishing.

Usually, if one-eighth of a rabbit is varnished, one-half of a horse, and one-quarter of a dog, the result is fatal from the above causes. Hence, the vast importance of keeping the skin perfectly clean; a daily bath should be taken by everyone. The hair, too, if possible, immerse; the woman cannot do this well, but the men can; their hair being short. Soap is an alkali and is universally used, but it is injurious in some rare cases. When this is the case, substitute cornmeal; it acts well, ordinarily. Some people depend upon the friction of their clothes against the moving parts of the body for cleanliness, but it is bad hygiene. The sebaseous secretion, and the animal solids left by evaportion, continuously form a solid film over the skin, which is invisible, yet it chokes up the mouths of the sweat glands (so-called "pores" of the skin), and greatly impede their activity.

Bathing in salt water is excellent. The salt has a slight stimulating effect upon the skin, and helps the afterglow. If simple fresh water does not agree with you, try salt in it. "Sea salt" is the best kind to use; generally find it in the shops. Narragansett bathing is about the warmest, and Cape May the coldest bathing, the author has ever tried, except, of course, for warmth, the Gulf bathing was found to be especially warm and invigorating, near the delta. It is said that bathing in the Salt Lake, near Salt Lake City, is not a bathing, but a "sitting," as you cannot "sink" in that marvellously natural creation of the hidden secrets. Keep out of the water when you are chilly, but it is safe to bathe when very warm, if you are not perspiring freely; then, it is dangerous. Bathe about 2 or 3 hours after eating; never, immediately after eating, as the blood is needed for the stomach and intestinal digestion of food. Cold bathing is not used much; more frequently, the chill is taken off, by some warm water. Warm baths, too, are bad, if regularly taken; they seem to diminish

the vital activity of the body. Temper the water to the pleasure point.

The excreta of the skin, as of all the body, is acid in reaction. The temperature of the body is influenced and somewhat regulated by the skin.

THE STRUCTURE OF THE SKIN.

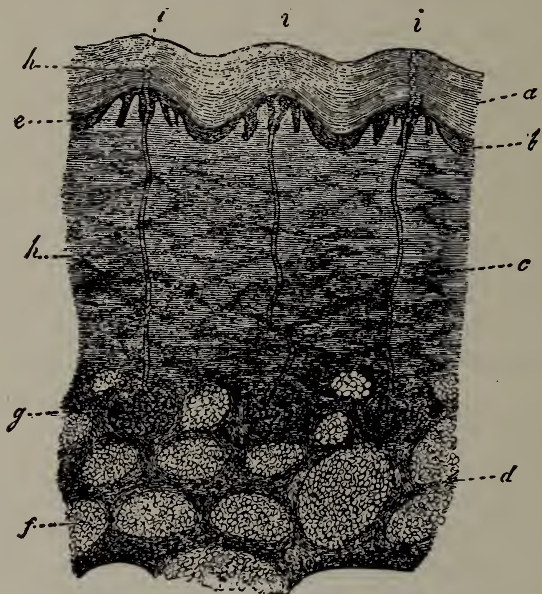

FIG. 65.—A section through the skin and subcutaneous areolar tissue. *a*, horny stratum, and *b*, Malpighian layer of the epidermis; *c*, dermis, passing below into, *d*, loose areolar tissue, with fat, *f*, in its meshes: above, dermic papillæ are seen, projecting into the epidermis which is moulded on them. *i*, opening of a sweat-gland; *h*, duct of ditto; *g*, the gland itself.

The skin all over the body consists of two distinct parts or layers; an outer, the *epidermis* or scarf skin; and an inner or deep layer, the *dermis, cutis vera* or *corium.*

Blister the skin and the fluid accumulates *between* these two layers

The *epidermis* is made of squamous epithelium, arranged in four or five layers, and united by a small amount of cementing substance. It is a hard and dry covering, varying in thickness; being thickest at the points most exposed to friction and pressure, such as the palms of the hands, and

soles of the feet, but this does not impair the function of receiving impressions at all. It seems to enhance this power, for they are more sensitive than the thinner parts, as the neck, thigh, etc. This layer does not contain any blood vessels, and few nerves, but the *true* skin is abundantly supplied with nerves, (being hypersensitive), and vessels. The cells of the epidermis are flat, round, elongated and generally irregular. The superficial cells are without the nuclei, of which the deeper ones are possessed; they easily die; dry and exfoliate when we wash and rub the surface briskly; their places being taken by new cells. The rolls of horny material peeled off the skin by the shampooing of the Turkish bath, or by rubbing with a rough towel after a warm bath, are the dead outer cells or scales of the horny layer of the epidermis.

In dark races of people, the color, mainly depends upon the amount of minute pigment *granules* found in the deep strata of the epidermis.

The nourishment of the epidermis comes from the true skin by *exudation* of fluids from the blood through the lymphatics, which are abundant in this covering.

The true skin, corium, cutis vera or dermis, consists of a close network of elastic and white fibrous tissue; it becomes wider meshed below, and gradually passes into the deeper areolar tissue, which attaches the skin loosely to the parts beneath. It is the true skin which "tanning" turns into leather; this with the tannin of the oak bark employed, forms an insoluble and tough compound which we use as shoe leather, harness, etc. The elevations of this layer are called *pappillae,* and the epidermis is moulded on this. Hence we have deep pits in the epidermis, and little mounds on the corium, the two, joining closely together to form the skin, proper, so important to us.

Wrinkles of old people are due to the absorption of the subcutaneous fat and other soft parts beneath the skin, which, the skin, not shrinking itself at the same time and rate, becomes thrown into folds, which we call "wrinkles."

Hairs are really epidermic developments upon the papillae specially adapted for the purpose; this reaches down into

the skin and tissue beneath, into a pocket or depression called a *hair follicle.* This receives the *root;* above, we find the stem; this tapers off to a *point* or *split end.* · These consist of the *scales,* coverings; the *cortex,* or long cell-layer; then, the

FIG. 66.—Parts of two hairs imbedded in their follicles. *a*, the skin, which is seen to dip down and line the follicle; *b*, the subcutaneous tissue; *c*, the muscles of the hair follicle, which by their contraction can erect the hair.

centre or *medulla,* made of rounded cells. This latter may be hollow and filled with air cells; or it may be filled with pigment granules, as the cortex. The presence or absence of the pigment granules influences the color of the hair, with the presence also of the air or not. In dark hair, pigment is in excess, and little air; in light hair, vice versa. We find slender bundles of unstriped muscles running from the dermis to the side of the hair obliquely. When contracting, the hair *stands up;* otherwise it lies down flat. Hair is found all over the body except on the palms, soles, the backs of the last phalanges of the fingers and toes, and the upper eyelids. The nerves influence the sudden change of color of the hair, from brown to white, etc., in a night.

Nails are highly developed horny parts from the epidermis. They are found at the ends of the fingers, toes and thumbs, and serve as protectors of the skin at the finger tips. The *root* is embedded in the dermis; the *body* is exposed, but fixed to the fingers beneath and free above, terminating into a *free edge.* The part which develops the nail is called the *matrix.* The little semi-lunar area near the root, which is whiter than the rest, is called the *lunula.* It is less vascular than the other parts, and it shows whiter. As the nail grows and is pushed forward it is increased in thickness, hence the free edge is the thickest part of the nail. If the nail is injured, external to the matrix, it will grow out again.

Glands. There are two kinds of glands to the skin, Sweat Glands and Oil Glands; the former are tubular; the latter, racemose in character.

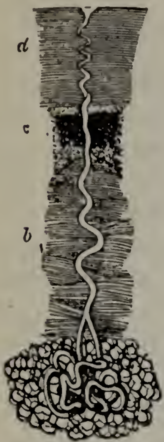

FIG. 67.—A sweat gland. *d*, horny layer of cuticle; *c*, Malpighian layer; *b*, dermis. The coils of the gland proper, imbedded in the subcutaneous fat, are seen below the dermis.

The Sweat Glands are found in the subcutaneous tissue. They form little globular masses, composed of a coiled tube. From this coil, a duct leads to the skin surface, spirally passing through the epidermis. The minute structure is complex, having a membrane, lined with epithelium. Blood richly circulates around these glands. The glands are found all over the body, but especially thick in the palm of the hand and about the brow. There are supposed to be about 2,000,000 or 3,000,000 openings on the skin surface, the largest of which are under the arms and about the genitals.

Sweat is principally water, and about 2% organic matter. Its sp. gr. is slightly more than 1010; its reaction when secreted is alkaline, but when it comes to the surface, is acid, owing to its contact with fatty acids. It contains urea, and a peculiar poison, fatty matter; its odor differs and also its color at times; drugs, like arsenic, mercury, turpentine, etc., may get into the sweat secretion and be eliminated thereby.

Hyperaemia alone will not cause sweating; the *nervous* influence is needed. We may profusely sweat from fright, nausea, excitement, exercise, fevers; you may then be pallid and yet sweat, a cold sweat. The cow, sheep, dog, etc., are not supposed to sweat; the cat sweats on its feet. Stimulate the sciatic of the cat and it will sweat on the ball of the foot; cut the nerve and it does not sweat. The sweat glands assist the kidneys in eliminating urea and poisonous matters.

The Sweat Centres are in the medulla and some others are found along the cord. There is one in the cervical region and in one of the lumbar region for the respective extremities. Sweating is an index of weakening. It is said that skin

grafted will not sweat till it becomes sensitive, therefore, nerves are highly essential to sweating.

The Sebaceous Secretion is only, semifluid and has a queer odor. It contains olein and palmatin in about 50%, and does not correspond to the size of the hair which it lubricates. These glands secrete the sebum by breaking up the protoplasmic cells, just as in the mammary glands. Friction assists their secretion. It makes the hair glossy; it also bathes the skin and helps prevent the watery fluids from permeating the cuticle. Water poured on a healthy skin runs off, as if "poured on a duck's back," only less markedly.

Ductless Glands are without ducts, but they are supposed to discharge their secretions directly into the blood channels. They are the spleen, thyroid and thymus glands, supra renal capsules, carotid glands and coccygeal.

CHAPTER XVII.

THE SPECIAL SENSES.

Sensations, are, properly speaking, produced from some centre of the brain. They are always, however, referred to the peripheral organs, such as the eye, ear, nose, tongue, skin, etc. If you cut these special nerves running from these organs to the brain, or vice versa, the special sensation is *lost.*

Consciousness is required to make a perfect and useful sensation, for if you are asleep, you do not see, hear, nor smell normally well, yet the same impressions are *received* by these organs. Chloroform anaesthesia will deaden these feeling-centres so that a limb may be taken off without the slightest sensation of feeling.

Different Sensations are found, in respect to degree, in different animals. The low orders have no special nervous apparatus, but, like the earth-worm, feel about as accurately in one part of the body as in another. Touch it, and its whole body wriggles; it feels about the same sensation over the entire body. Cut it into two pieces, and each half, alike, feels the sensation. The higher the type of animal, the more, and infinitely more complex, are these special organs of sensation. These specified organs are not separated from the rest of the body, but are simply outshoots and parts of the whole.

Contract, by external sensations, is the simplest form of special senses, and the lowest animals possess it; some, to a very marked degree. Shape, size, sound and color, are for higher powers and organs.

Sensations are greatly modified by exercise and moderate use. Excitement dulls them. The *Indian* has acute *hearing* powers from long moderate training exercise. The *sailor* from keen practice *sees* better than we. The *blind* and *touch perfection,* is in *some,* wonderfully developed. These illustrate the help which moderate practice lends to special development. Now, take such cases as the *boilermaker,* or the

man who uses *hot condiments* with his food, and they lose the faculty of *hearing* and *taste* to a marked degree. We get *used to* the *ticking* of a clock, or the *hammering* of the muscular blacksmith, from the deafening exhausting play on the same set of nerve fibres. They get tired temporarily, and *refuse to hear*. In old age, and in childhood, hearing, etc., are deficient, and in the former becomes less vivid; while in the latter they increase rapidly with development.

Sensitive and Insensitive Parts. Sensation may or may not be felt in some parts of the body. The brain is insensitive, and may be pinched or cut without pain. The hair, nails, epidermis of the skin, the cervex uteri and bones and ligaments are very slightly sensitive, if at all, because they have no *nerve supply*, except the latter, which are slightly supplied with nerves. But the true skin, mucous linings, such as those of the nose and eye, have an extremely sensitive feeling. The *nerves decide* the degree of *sensibility* of a part, hence in operating, it is most painful to the patient when the surgeon cuts through the true skin, because of the network of fine nerves. Spray the part with ether, and you can easily operate with little pain.

Excitability of a part is beyond pleasure and becomes painful, as in tickling a child, etc. *Pain*, then, may be pleasure intensified. The sympathetic nerves may and do have very little sensibility during health, but in disease they become hypersensitive. Sunlight is, moderately, pleasant; but the strong direct rays cause pain, and may cause blindness if looked at too long. These hypersensitive parts of the body are our guards.

Pain warns the higher nervous centres, to stop doing whatever irritates certain parts. It thus protects the part, and requires it to rest; if we are sensible beings we act as nature dictates. It is the herald of most diseases; it teaches us to exercise, moderately, and not violently. Disease, by early writers, had reference only to "want of ease, or pain." Many grave injuries have occurrred by the absence of the pain-guardsman; a paralytic may scald his foot by putting it in very hot water, and not feeling the pain, he cannot realize the danger. The cold, hungry traveler, overcome by cold

and exhaustion, stops, builds a fire and falls asleep. In the morning, when aroused, he finds one foot burned to a crisp—destroyed. Why? The cold having numbed the nerves, pain could not warn him, and hence the fatal result. Pain, we imagine an irritant of the evil spirit, yet it is indeed our best friend and sentinel. It really tends toward restriction, or temperance in eating, exercising, drinking, pleasures, etc. Pain in the lower animals is supposedly not very acute. If you will not work, and will eat, pain, it is, that first sounds the warning of prudence. Pain in the big toe indicates gout; in dyspepsia, ordinary pain in the forehead may be the index of the malady. The story of the butcher, who slipped while hanging a ham on a sharp hook, and who cried out from pain, even taking the clothes off seemed to cause him great agony. But after removing all the clothing, not the slightest scar was found; he *saw* the danger, and *thought* he *felt* the pain, but was mistaken. Nature sometimes, then, is in error.

SPECIAL SENSES AND THEIR INDIVIDUAL SENSATIONS.

The Special Senses are Touch, Taste, Smell, Sight, Hearing, and some name Temperature as one. Special organs are requried for these special functions, viz: the hand, the tongue, the nose, the eye and ear. These all have peculiar ways of receiving impressions and stimulus. The ear replies to waves of sound; the eye to waves of light, etc.; the organ of smell, cannot appreciate waves of sound or light, but it can and does detect the fumes of different bodies, which send out odors varying in strength and pungency. Different forms of nature are distinguished by these special functions of the special senses. But for these senses, we could not appreciate the beautiful sunset; the excellent music, nor any of the finer appreciable qualities of nature.

These special senses are related very closely in action. It is said that a blind man attempting to express his notion of scarlet, said it resembled the sound of a trumpet. The dull black of the object reminds the ear of some, to the bass note of music. Snuffing a volatile salt may remind you of seeing stars from a blow on the head.

Sweet things are numerous ordinarily. We call an apple, sweet; a rose, sweet; a man, sweet; a child, sweet; a face, sweet; music, sweet; love, sweet, and even adversity, sweet. The mind and the special sense of sight, hearing, etc., get too, closely allied, and therefore, confused in their functions. Hence the assistance of one sense by that of another. To hear well, we open the lips and part the teeth slightly. To detect a delicate taste, or remember a faded impression or name, we listen and turn the eyes downward and inward. The brain is the real origin.

Differentiation of senses is simply an economy of the nervous force, as in the secretory, etc. This is only an apt division of labor for our best results; and these, we attain by using these special organs for special purposes. Our consciences, or inner sight, or third eye, as some call it, preside over these special functions, and influence them markedly. For example, naturalists say that if you seal the eyes of a bat, and then let loose in a room crossed by many wires in different directions, it will fly in and around them and not touch any of them, just as if it had other means of perception than the seeing eye.

Laura Bridgman could neither see, hear, nor smell, yet she had the power of detecting the presence of a stranger in the room, and without contact, too. How? We know not. The mind got some influence or impression from the touch-sense, possibly. How acute indeed, was that invisible sense of hers. Was it intuition, or a sensitive skin perception?

Touch. The skin, covering the entire body has this function highly developed. Many and numerous little nerves end in minute brushes in the true and false skin. The hand is ordinarily the most important organ of touch. Its mobility, its highly sensitive skin, which is fine and is, a real network of nerve terminations. These nerves end in a papilla, or cone-shaped eminence; in a square inch of the ball of the finger or palm of the hand there are about 20,000 of these small eminences. The epidermis is necessary for the sensation of touch, for when this scarf skin is injured by a burn or otherwise, you can only feel pain as the sensation. Hence the very great importance of the epidermis in touch-impressions.

Destroy the epidermis and the touch-sense is destroyed; but the sense of pain is present; but that is pathologic and not physiologic in function. We may say that the skin—the epidermis part of it is simply used as a protection for the nerve endings, and thus they do not come in *direct* contact with external substance, dead or alive. In some parts of the balls of the fingers, touch being here highly acute and most delicate, the skin is padded underneath with a permanent buffa of very elastic tissue; and the nail, being placed in a firm matrix of tough fibrous tissue, gives the part additional solidity and protection from the opposite side of the finger tips. The anatomical arrangement of the whole arm is such that we have excellent mobility of the part and can come in contact with objects most easily and quickly. Though delicate and pliant, tapering and slender and composed of many small bones, the hand is nevertheless a most powerful organ, and can withstand an enormous strain.

Philosophers, have always been attracted and interested in the hand. Palmists have carved out their livelihood for many years by the art of hand study. Some learned scholars have asserted that man has attained his great fund of knowledge, and further, has achieved his lofty height of "lord of creation," because of the hand. It is claimed by Buffon that, with fingers twice as numerous, and twice as long, we would become twice as wise." Some great philosopher has said that "no one can study carefully the human hand and fail to be convinced of the existence of the Deity." Galen, the great anatomist and scientist, took an equally high stand, yet he was possibly more reasonable in saying that "man is the wisest of animals, not because he possesses the hand, but because he is the wisest, and understands its use; for his mind, and not his hand, has taught him the arts." However, we know the intrinsic value of the hand, and appreciate it accordingly.

The Delicacy and Sense of Touch is greatly assisted in the use of the hand and skin by contact and prehension. Touch begins earlier and lasts longer than any other special sense. The simplest and earliest reflex act of the child, it naturally gains some knowledge of the outer world by simply

touching things, and the brain and mind do the rest. Many intricate theories and problems of nature and her laws are felt out by this tactile sense. Size, shape, certain temperature, solidity, motion, the smoothness or roughness of substances and many other important sources of knowledge are gleaned by this function of touch.

The other senses are greatly assisted by the touch sense, especially that of sight. The story of the boy who, after having been blind 12 years, received his sight, said to the cat, after finding that sight and touch were closely allied, "Puss, I shall know you next time." He learned by touch, to see, while blind; he could not tell, at first, the difference between a cut circular card and a globe of the same color, till he felt them, or touched them. Touch is the least liable to error of all the senses, yet by removing that part of the skin, and thus removing the customary position of contact, as in the new nose flaps from the forehead flap, a false impression is created in the mind. Aristotle proved this by an experiment with two fingers crossed and placing a marble between the crossed tips; the impression is conveyed that there are two instead of one marble; try with the tongue and two tongues will be felt. Nerve union, after an accident, is very important, and hence our many cuts on hand and fingers are not permanent injuries, for the nerves unite and retain that touch sense.

The tips of the fingers of some artists are said to possess the touch sense to such a high degree, that they are supposed to have special little cell developments at the balls of the fingers. Such men as Blind Tom, Paderewski, etc., as well as skilled surgeons, and painters, have these senses especially well developed. This sense is fifty times more delicate in the finger tips than in the posterior part of the back, and shoulders. The sculptor knows the value of touch, likewise the physician. The born blind have the highest development of the touch sense.

Temperature is a common sense, and with it *Muscular Sense* is also considered. Each have been supported as the sixth special sense. Both vary under different circumstances and are not reliable. Muscular sensation refers only to

weight, burden, and it therefore assists force-exercise, in lifting, etc. The skin tells us if a thing is hot or cold; sight sometimes may. *Temperature,* then, is often very valuable, as an aid to sight. It is said by Weber that warm bodies feel lighter than cold ones. The dog's skin shivers when he sleeps, not because he is cold, but because nature dictates to it to keep in motion or friction, and thus generate heat sufficient to maintain the body functions without taxing its energy. In locomotor ataxia, the patient stands erect so long as he can *see* his limbs, but the instant he closes his eyes, he totters and will fall, if not supported.

The Eye is the organ of sight. It is well protected by a deep bony triangular cavity running into the central part of the face and forehead. Around the outer bony cavity is a rim of thick strong bone, made especially to protect the eye from external violence. The eye is protected further by two splints or curtains, which are cartilagenous, and membraneous internally and cutaneous externally. These are the *lids.* The upper one has a structure which, beginning from within out is particularly smooth and abundantly supplied with blood and nerves, the *conjunctiva;* then the outer covering which is integument, loosely placed; and between the two, we find the fibro-cartilage, blood and nerves and connective tissue. The lids are freely movable curtains, which have on their free margins, fine short curved hairs arranged in one or two rows. These prevent numerous cinders, straws, etc., from getting into the eye. The eyebrows, too, just above the eyes, help to prevent foreign bodies from getting into the eye. The upper lid is more mobile than the lower, and it covers all of the transparent and delicate part of the eye when closed. The *levator palpebrae superioris* muscle, raises this lid; and the *orbicularis palbebranum* muscle lying on and around the lids beneath the skin, closes them. These lids are united at the outer and inner parts of the eye, called outer and inner *canthi.* The real size of the eye depends upon these canthi, whether separated widely or not. At the inner canthus is a small eminence called the *lachrymal papilla,* on the lid; and at the angle of the inner canthus is a fleshy body called the lachrymal body. The lids are in contact with the

external eyeball, except near their inner edge; there, a red vertical fold of conjunctiva, the semilunar fold intervenes This is a remnant of the third eyelid, found in many animals largely developed. In birds, this can be drawn all over the eyeball, and serves as an extra protection. Behind the fibro-cartilages in the lids are about 20 minute, compound sebaccous glands, (Meibomian); when dried, it causes the lids to stick together, in some cases; in health, its oily composition prevents an overflow of tears over the edges of the lids, besides moistening the edges and preventing their becoming dry and crusty.

The Lachrymal apparatus consists of the tear-gland, the ducts which convey the secretion to the upper eyeball and lid, and the canals by which the excessive secretion is carried off from the whole eye into the lower part of the nose. That is why we have to blow the nose after the hypersecretion, from crying, irritation, etc. The *lachrymal* or *tear gland,* is situated in the upper and outer angle of the orbit, so situated that the inward motion of the lids presses the secretion universally well all over the eyeball. It is about the size of an almond, and is a compound lobulated racemose gland, with about 12 or 15 minute ducts opening in a row at the outer corner of the upper lid. The two small *lachrymal canals* began as small openings on the edges of both the upper and lower lids near the inner canthus, and running upward and downward, respectively, a line or two, then turn toward the nose and open into a dilated *pouch* or *sac,* just outside of the nose, thence into the *nasal duct,* which empties into the inferior meatus of the nose. If these ducts become occluded from disease, the surgeon has to open them, to prevent the tears from running over the cheek and irritating it. In old people, too, the lid may not fit close to the eyeball and thus prevent the tears from getting into the ducts, and hence, the red lids and cheeks from overflows of tears, which we so often see. But for this secretion, the eye would become dry and lustreless, similar to that of a fish after taken from the water. Wind, bright lights, dust and many diseases and emotions cause the tears to flow excessively. The child "gulps

down his passion" we say, yet it is the overflow of tears it swallows.

Winking occurs about 6 or 8 times a minute, and the lids in this act move inward and together, thus pushing the fluids which moistens the whole eye or cinders, etc., toward the ducts and inner canthus.

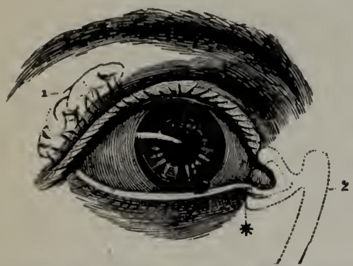

FIG. 68.—FRONT VIEW OF RIGHT EYE (Natural Size.)
1. The Lachrymal, or tear gland, lying beneath the upper eyelid.
2. The Nasal Duct is shown by the dotted line. The * marks the orifice in the lower lid.
The central black spot is the *pupil;* surrounding it is the *iris;* and the triangular white spaces are the visible portion of the *sclerotic.*

For ordinary removal of a cinder, loosely caught under the lids, it can be removed easily by placing a matchstick midway between the eyebrow and the extended upper lid border or lashes and then press lightly and invert quickly. In most cases the foreign body is then readily seen and wiped off with a clean silk handkerchief. If embedded in the eye substance, consult a physician at once.

The Eye is the organ of sight. It has been considered the outshoot of the brain, and "the window of the soul." The eye is an organ of extreme beauty, and its function is of great importance. We can examine the external eye with great ease, with a little practice, but to examine the interior of the eye is quite difficult. There are many instruments now invented with which to examine the interior—the lens, the retina, the optic nerve and vessels. The most important one is the opthalmoscope, and the four-inch lens. New operations also have been performed in which blind people have been restored to sight and dread diseases cured. There are two eyes, perfectly independent, yet closely and intimately associated in seeing and recording vision. So in the loss of one eye does not impare sight completely, though it may partially. Its location is for the best advantage in seeing moving objects or the ordinary fixed ones; its range is wide and it is freely changed, to suit the conditions, by the muscles.

The Muscles of the Eye. The eye is spheroidal in form and is connected intimately with the brain by the optic nerve, just as you would hold an apple on a round stick. On the exterior of this eyeball are inserted the tendons of six muscles, four *recti* or *straight* and two *oblique* muscles. The recti are, one superior, one inferior, one internal and one external; and one inferior short, and superior long and irregular, oblique. They all, except the inferior oblique, arise from the bony margin of the foramen through which the optic nerve enters the orbit. The inferior arises near the lachrymal sac anterior to all the others.

The third nerve supplies all the muscles except the external rectus and superior oblique. The external rectus is supplied by the 6th nerve and the superior oblique by the 4th cranial nerve. Thus, we have muscles to move the eyeball in every direction. When these nerves supplying the muscles act inaccurately and irregularly, we have *squint* or cross eyes, or external squint. Dropping of the upper eyelid, which covers the ball of the eye, from paralysis of the lid muscle is very serious indeed, and it may lead to some brain trouble, primarily as the cause. So we find that we have two parts of the eye to study, the external or protecting and draining parts, which we have just described briefly, and the optical organ proper, the eyeball, which we will now very briefly explain.

The Globe of the Eye is the eyeball, which is really a continuation and termination of the brain substance, called the optic tracts. It is comewhat spheroidal, but is composed of segments of two spheres. One is more than a hemisphere, the larger part; the other is less than a hemisphere, the smaller, and it is the most transparent portion of the eye, The eye is about 1 inch in its diameters, but the lateral diameter is slightly greater than the antero-posterior diameter. The eyeball is, generally speaking, composed of three tunics or coats, and three refracting media or humors.

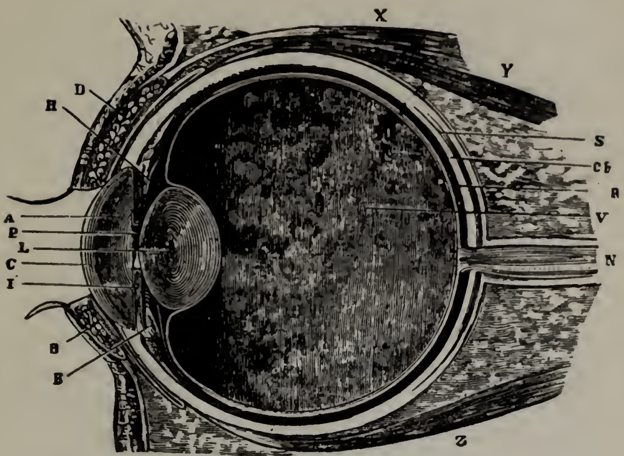

FIG. 69.—VERTICAL SECTION OF THE EYE. (Enlarged.)

C, The Cornea.
A, The Aqueous Humor.
I, The Iris.
P, The Pupil.
L, The Crystalline Lens.
H, The Ligament of the Lens.
B, The Ciliary Process.
V, The Cavity containing the Vitreous Humor.
S, The Sclerotic.
Ch, The Choroid.
R, The Retina.
N, The Optic Nerve.
DD, The Eyelids.
X, The Levator Muscle of the Upper Lid.
Y, The Upper Straight Muscle of the Eye.
Z, The Lower Straight Muscle.

The outer tunic is the *sclerotic* coat, a white, strong, fibrous, opaque shell which covers the back and sides of the eyeball and we see it as the "*white* of the eye." It is continued on in front as the *cornea,* which is transparent and formed into about 60 different layers, the outer is called *conjunctiva,* the inner the *membrane of Descemet,* which is extremely elastic, and lined internally by a single layer of epithelial cells. Both the cornea and sclerotic are formed of the same kind of tough connective tissue, but the *sclerotic* is *opaque,* being intermixed and irregularly arranged for strength and protection to the more delicate internal structures; it is sparsely supplied with blood vessels and nerves, and can be touched with the finger without much pain, because of its insensibility. The conjunctiva covers the anterior two-thirds of the *sclerotic.* Then the continuation of the sclerotic coat forward is the *cornea.* The cornea is highly transparent and thus allows light to pass into the eyeball and reach the retina: which really is the most

important eye structure. The conjunctiva is one of the outer coverings of the cornea, too; the cornea is somewhat similar to a small watch glass, and is about 1-25 of an inch in thickness; its structure, like a horn or fingernail, being destitute of blood vessels, but very transparent, and its many different layers are stuck together by a transparent glue. The sclerotic makes 5-6 of the eyeball, and the cornea 1-6 of the whole, which is in front. The sclerotic coat comes from the word *scleros,* hard. It is perforated at the nasal side of the posterior central aspect by the optic nerve, and as it continues forward, its *irregular structure* stops, at a certain ciliary point and continues over the front of the eyeball as *parallel layers,* which we found were transparent and about 60 layers in all, called the cornea, as above.

The second tunic or coat forms not only its own middle coat, but also the *ciliary bodies* and the *iris.* The *choroid* or middle coat is unlike the outer shell of the eye, in being very soft and delicate. It has a great blood and pigment supply, being very dark from its dark brown cells, spread over the inner layer of surface. This dark lining serves to absorb the rays of bright light, after they have passed through the transparent structures in front of it. If this were not the case, confused vision would result within the eye, from too numerous images impressed upon the retinal optic nerves.

Opticians imitated this mechanical device when they coated the interior of the tube with a thick layer of black paint or lampblack, because yon cannot clearly delineate the object unless this is done. In white rabbits these dark cells are wanting, and so with other animals with pink eyes. They cannot see well in a bright light. Albinos have very few dark cells in their choroid coat, and hence their bad vision. Blondes also have weak eyes, as a rule, from deficiency of these pigment cells.

Ciliary Processes. These plaits are thrown thus by the thinning of the choroid; as it begins to diminish in thickness, the choroid continues forward as the iris.

The Iris, meaning in Greek (rainbow) the curtain that lets in or prevents the entrance of light to the interior of the eye. We see this colored gray, blue, dark, etc., through the

transparent cornea. The dark part of the eye which we see is the iris, and not the cornea; the iris is the background, and the cornea, being so clear, allows the light to pass easily through to this dark membrano-muscular curtain; it is circular and extremely muscular, vascular and freely supplied with pigment corpuscles in the inner surface of the iris. In the centre of the iris is the pupil, or in olden times spoken of as the "apple of the eye." It is a circular aperture, which is regulated by the two sets of muscular fibres; one, a circular set around the margin of the pupil and narrowing it when they contract; another set radiating from the centre to the outer margin of the iris, and when they contract, dilating

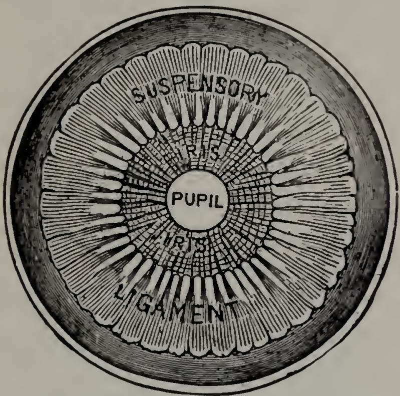

FIG. 70—Front Section of its Eyeball, viewed from behind, and showing Suspensory Ligament, Iris and Pupil.

the pupil; these last resemble the spokes of a wheel radiating from the hub, considering that the *hub* is the *pupil* of the eye. The second layer, then, does not completely envelop the eyeball, as the sclerotic and cornea combined. The action of the pupil is purely reflex in character; darken the room and the pupil enlarges to let in more light; brighten the room and the pupil contracts, shutting out certain irritating rays of the light. This action is slow, as seen when you pass from a light to a dark room, or vice versa. The lustre of the eye is affected by the size of the pupil; if large as found in youth, it is bright; if small, as seen in the old, it is dull. Belladonna, meaning in Italian, "beautiful lady," dilates the pupils and is largely used by the women, hence its name. It is a

poison, and should be carefully ordered by a physician only. The English name is "Deadly Nightshade" for the same drug. So this iris or curtain is a continuation of the choroid coat; just as the cornea is a continuation of the sclerotic.

The Retina is the inner and most important, as well as most complex of the three tunics. It is the part of the eye in which light produces changes which give rise to impulses in the optic nerve. It is a less complete envelope than the middle tunic, for it ends forward at the ciliary processes or bodies. It is transparent, if fresh, soft, delicate but intricate, in structure; when examined early, it has a faint purple color, or almost colorless. The outer layer has some black pigment cells. The two peculiar parts of the retina are the *optic mound,* locating the entrance of the optic nerve, this, entering through the sclerotic and choroid coats and spreading out over the retina. The other peculiar spot is called the "yellow spot," found directly in the middle line of the course of the light on entering the eye. In its centre it is thinner than outside further, hence there is a small pit called *fovea centralis.* It appears black or dark, because the thin transparent retina allows the black choroid to show through. The artery which supplies the retina enters by perforating the optic nerve and entering in that manner, and later diverge as seen in the examination of the eye.

The Retina is extremely complex, being composed of 10 layers, as seen in the following diagram. The *cones* are the

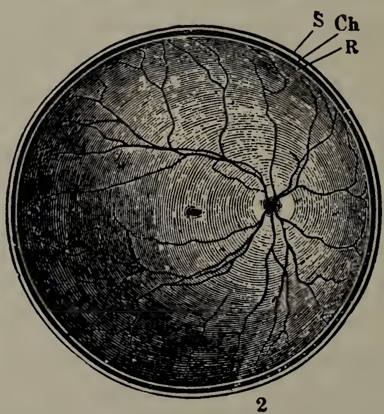

FIG. 71.—The right retina as it would be seen if the front part of the eyeball with the lens and vitreous humor were removed.

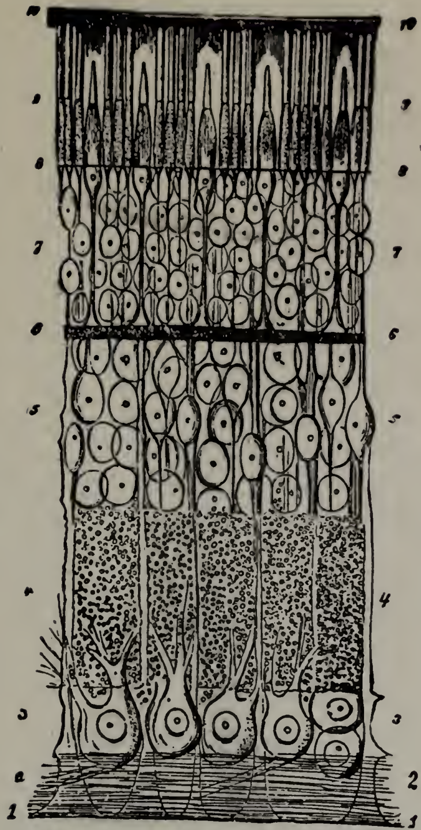

FIG. 72.—A section through the retina from its anterior or inner surface. 1, in contact with the hyaloid membrane, to its outer, 10, in contact with the choroid. 1, internal limiting membrane; 2, nerve fibre layer; 3, nerve-cell layer; 4, inner mo ecular layer; 5, inner granular layer; 6, outer molecular layer; 7, outer granular layer; 8, external limiting membrane; 9, rod and cone layer; 10, pigment-cell layer.

important factors in vision; they and the rods are massed into one layer. The cones are in excess in the central part of the eye where most light and visions are found. Light alone seems to affect the retina; pain nor touch sensation is experienced on the retina by irritation. Flashes of light are caused by pressing or irritating this nerve; a blow or fall, we know, causes a flash of light or causes us to "see stars." This is only due to the peculiar special sense of sight of the optic nerve. "Dazzling" is only a sense of peculiar pain of the retina. It was claimed in a German court that the assailant's

features were recognized by this power of the retina while the party was being assaulted, but physicians denied this, claiming that the blows on the head prevented this.

At the entrance of the optic nerve is a "blind spot," which is easily proven by optical experiments. The duration of a retinal image is about 1/8 of a second. This organ is very sensitive and easily fatigued. Winking rests the retinal action momentarily. Fix the eye upon the red wafer on a white background and on removing the wafer a greenish spot of the same shape is seen. The retina has exhausted its power to see red, and perceives only the complementary ray, green. Color blindness comes from this defect of the retina. Signals may thus be mistaken and ship and railroad accidents occur, from failure to see the correct light of danger. Daltonism is color blindness; it may mean also music blindness.

The Refracting Media of the Eye are, from front to back, the *cornea,* the *aqueous humor,* the *crystalline lens,* and the *vitreous humor.* The *aqueous humor* is found in the space between the front of the lens, and the back of the cornea. The iris divides it somewhat into two chambers, anterior and posterior. This fluid is water and salty materials, and about 5 or 6 drops in quantity.

The Crystalline Lens is biconvex in shape, colorless and transparent, with the anterior surface less curved than the posterior. A capsule surrounds it, and the inner edge of the iris lies in close contact with it, and in disease may adhere to it permanently, if not dilated by drugs. It is somewhat soft, with the layers toward the centre more dense. Pressure from adjacent parts keeps the lens in position, with the assistance of its capsule. Its structure is elastic, being only about 1/4 of an inch thick. If the lens, from trauma or disease, becomes opaque, and does not allow light to pass through, blindness results. In old people, this may happen very frequently; however, in this class, they become blind very slowly. When dry, it can be pealed off in scales.

The Vitreous Humor, somewhat resembling melted glass, is a soft jelly, enveloped in a thin capsule, the *hyaloid membrane,* which splits as it reaches the lens and forms its *suspensory ligament.* The *canal of Petit* is found between

the split parts of this hyaloid membrane. This humor consists of water, salts, a little albumen and very little mucin. It is divided up into compartments by a delicate transparent membrane which holds its more liquid portions imprisoned, and which also lies very close in contact with the retina.

The Ciliary Muscle. Surrounding the eyeball where the cornea joins the sclerotic is a little vein called the *canal of Schlemm.* It drains the anterior eye just as the ditch drains the field. Lying on the inner side of this canal, where the iris and the ciliary processes meet, there is some plain muscular tissue, found principally in the middle coat of the eye, and forming the ciliary muscle, composed of circular and radial fibres.

The Uses of the Crystalline Lens. Being convex in shape, the lens has the power of converging the rays of light which pass through it, and the point of meeting of these rays inside of the eye is termed its *focus.* A magnifyng glass of similar shape to the lens, held in front of an open window, so that the sunlight will focus on a piece of paper correctly held will depict a part of the outside scenery, *inverted* or upside down. You will also notice that the point of focus is the brightest point. You can also bring the rays of light to such a strong focus by an ordinary burning glass lens that the paper burns, as the schoolboys usually well demonstrate.

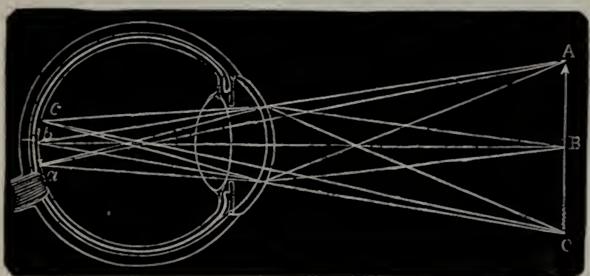

FIG. 73.—The Retinal Image. (Inverted.)

If you remove this lens from the inside of the eye, as in cases of complete cataract, the rays of light are not well focused, and the result is bad or scattered vision; the image is then too large, and the focus is behind the retina. The mind translates all these images and inaccuracies and hence we thus learn to see, or look at things.

Sometimes we have a long eye, and the focus of light falls short of the retina; this is called myopia or shortsightedness; and we use a minus glass lens on the outside in the shape of glasses to correct the defect. If the eye is short or flat, the focus goes beyond the retina, and this is called *hyperopia* or longsightedness; for this you use a convex lens to shorten the focus. The formation of the cornea, or lens, being too prominent or too flat, may influence the focusing power considerably too, but most of the defects are found in the congenital formation of the globe of the eye.

Accommodation is the power of the crystalline lens to become more convex or to relax and flatten, and thus control the focus of light to such an extent, that we are enabled to see objects at a distance, and also near at the same sitting, by this simple changing of the lens. This is a great power and is most necessary for our information and pleasure in acquiring knowledge generally. Schools and the near things they are compelled to examine carefully with bad lights, cause many eye diseases called nearsightedness, among the scholars. Dr. Agnew claimed that 17% of the children had bad eyes, and in universities not one-third had normal eyes. On account of old age or shrivelling of the lens, people, and espepecially women, need glasses at 40 or 45 years of age. And the more the lens shrivels, the higher the power of the magnifying glasses worn outside.

The Blood of the Eye comes from the long, short and anterior ciliary arteries, and the retina is supplied by the arterae centralis retinae, which enters in the centre of the optic nerve. These are all branches of the opthalmic artery, which also supplies the muscles and tissues generally.

The Nerves of the Eye. The motor oculi supplies all the muscles but two, the superior oblique and external rectus. The superior oblique is supplied by the fourth cranial, and the external rectus by the sixth cranial nerves. The ciliary nerves, branches of the trifacial, supply the coats and iris of the eye, and the optic nerve entering these coats to supply the retina with its delicate sense of vision.

The Ear. The organ of hearing is confined within a very dense part of bone called the petrous portion, from *petrous,* a stone. In the animal it occurs in the simplest form,

being merely a sac, lined with a sensitive membrane and filled with a fluid. Naturally if there is any agitation of the medium in which the animal lives, waves are then caused in the fluid of the sac, thereby striking upon the sensitive membrane, produces a thrill or vibration in the nerve, and this, being transmitted to the nerve centre, is interpreted as *sound*. A degree higher is represented as the ear proper, which has extra of the sac and fluid, minute bones which are highly important factors within the cavity of the ear, and which markedly increase or magnify the impression of the waves of fluid upon the sensitive nerves. These nerves are soft, and readily influenced by the fluid waves.

In the human ear we find all the internal parts similarly arranged, but much more intricate in anatomical structure and arrangement. It has an *internal, middle* and *external ear*, the most important of which is the internal ear, the other two only being accessory organs to assist in sound formation. It is hearing, then, that makes us familiar with *sounds*.

What is Sound? We found that it consisted of impression made upon the ear structures by certain vibrations of either fluids in the simple ear or of special elastic bodies in the human complicated ear. These sensitive properties are usually promoted and equally propagated by means of the air we breathe; this air is thrown into delicate undulations in many directions from the vibrating substances, just as a series of waves in circular form are set in motion when a small stone is thrown into smooth water; these waves increase in size but diminish in force as they move on. So the sound wave is similar to the fluid wave. The sound wave, however, is *spherical* instead of circular, and it goes at the rate of about 1,000 to 1,100 feet per second, or one mile in five seconds. Sound travels faster in water than in air; about four times as fast; through solid bodies, like rods or wires, etc., still faster. All solids, rocks, hills, mountains, etc., are good conductors of sound. We can place our ear at the edge of the railroad track and hear at a great distance the approach of the train; so the Indians place their ears to the ground to distinguish the approach of troops, travelers, etc. They know the sounds between horses, buffaloes and numer-

ous other animals. Place a stick at the ear and scratch the other end with a pin and the sound is greatly magnified at the ear. Air is necessary for all these sound formations, yet it is not the best conductor, as just shown. In a vacuum, sound is lost entirely; this is easily shown by ringing a bell in an exhausted air chamber or vacuum. No sound is heard after the air is removed, ring as you may. Let the air be now slowly pumped in again, and the sounds become more and more distinct, till finally, it is fully as distinct as before the air was removed.

Pitch of sounds depends upon the degree of rapidity of the sounding bodies. Quicken the number of vibrations, and the pitch will be acordingly higher. These notes of sound vibrations have been measured by musicians and they found that if they are less than 16 in a second, no sound is audible; and if these vibrations exceed 60,000 per second, it is painful to the ear structures, and also the sounds become extremely faint, and may be lost completely. Ordinary hearing ranges between 100 and 3,000 vibrations per second. Many people cannot hear a cricket chirp, because its vibrations are above 3,500 vibrations per second, and clear. Miss Yah, who recently had an injury occur to her vocal chords while reaching her highest soprano note, had 3,000 vibrations to the second; so high could her voice ascend that many in her audience could not hear her sing the highest notes.

The External Ear is composed of the *pinna,* which is cartilagenous in structure and differs in size and shape in all kinds of animals and humans. The second part of the external ear is called the *auditory canal;* both make the first part or external ear. The *pinna* consists of a somewhat flat, flexible piece of cartilage, projecting from the side of the temporal bone slightly, being attached to it by ligaments; and having three small weak muscles to move it. In the lower animals these muscles, as also the pinna, are highly developed and freely movable. In man they are small, and are only rarely endowed with motion. The pinna has from its peculiar shape been likened to a shell, hence *concha* is applied to it. This appendage is supposed to collect or bring to a focus, sounds, but it does this only to a limited degree; for if re-

moved, it only takes the ear about five days to regain its former acuteness of hearing. It seems to be more necessary in the larger animals, mule, horse, elephant, etc., as a trumpet for the ear than smaller ones; although, the carnivorous

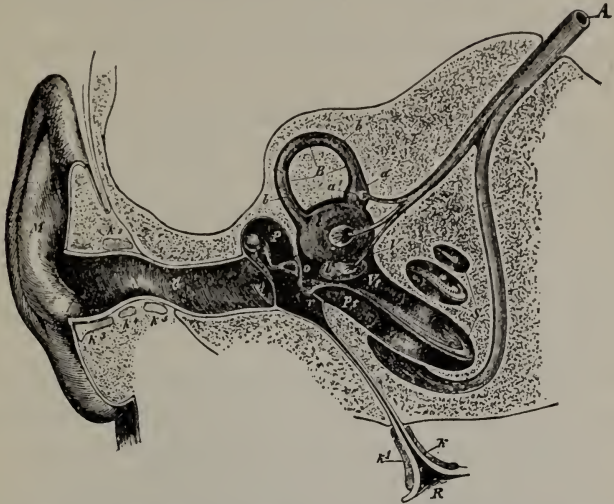

FIG. 74.—Semidiagrammatic section through the right ear (Czermak). *M*, concha; *G*, external auditory meatus; *T*, tympanic membrane; *P*, tympanic cavity; *o*, oval foramen; *r*, round foramen; *R*, pharyngeal opening of Eustachian tube; *V*, vestibule; *B*, a semicircular canal; *S*, the cochlea; *Vt*, scala vestibuli; *Pt*, scala tympani; *A*, auditory nerve.

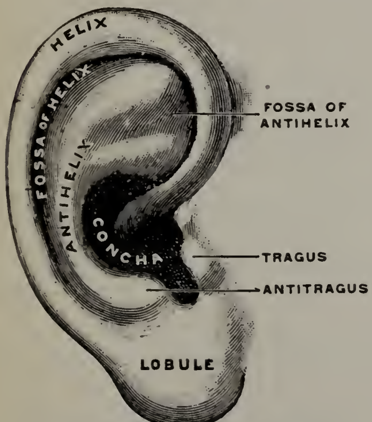

FIG. 75.—Right pinna. (Testut.)

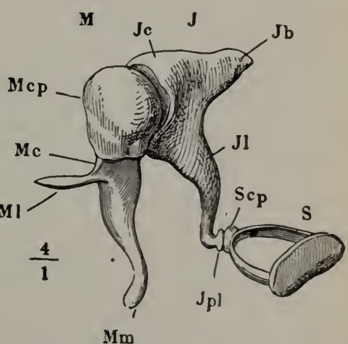

FIG. 76.—The auditory ossicles of the right ear, seen from the front. *M*, malleus; *J*, incus; *S*, stapes; *Mcp.*, head of the malleus; *Mc*, neck of ditto; *Ml*, long process; *Mm*, handle; *Jc*, body, *Jb*, short and *Jl*, long process of incus; *Jpl*, *os orbiculare;* *Scp*, head of stapes.

animals have the concavity directed forward, and the timid rabbit, backward, yet the former ones seem to have the power of turning their pinnae in any direction. It is noticed that fishes have no outer ears, their many different sounds being transmitted by what we call bone conduction. The sound waves pass into the internal ear through the solids of the head.

The Auditory Canal is continuous, with the outer opening of the pinna, internally, about 1¼ inches; then it reaches a close-fitting circular membrane called the *tympanum* or *drum*. This limits internally, the external ear and auditory canal. This canal is formed of skin and membrane, which is similar to skin. It is oval in form and slightly curved forward and inward in its course, so that the inner extremity is not in full view.

Hairs are found guarding this external ear, which in the young are very fine, but in the old become more and more wiry. They guard the orifice from intrusion of insects, etc. *Ear wax,* too, secreted by a number of little glands, is very obnoxious to insects generally; it is yellow, bitter and as fast as the outer layer of this waxy substance dries and falls out as thin hard scales, a fresh supply takes its place, as the minute glands secrete continuously. If an insect tries to enter this external ear, it meets the hairs first, as in the nose entrance, and may turn back then; but if it continue, the wax, being sticky and extremely bitter, will cause it to quickly turn and come out if possible. Often, however, they fly in with great force, and lodge inside for some time. In such cases, as in the entrance of beans, pencils and sticks with many other foreign bodies, we have to consult a physician to remove them. In some cases the wax hypersecretions mixed with the skin exfoliation, form hard deposits in this canal and make it especially difficult to remove them.

The *Blood supply* comes from the posterior auricular and superior temporal.

The *Nerve supply* comes from the great auricular temporal, posterior auricular and small occipital.

The Middle Ear or Tympanum is situated between the external and internal ear. The middle ear, like the internal

ear, is found in the petrous portion of the temporal bone. It has a roof which is formed by a very thin plate of bone, separating it from the cranium. It is deep, narrow, long and cleft-like. The floor is very narrow; the inner and outer walls present the greatest expanses of surface; then they converge to its floor into a long channel called the *Eustachian tube,* the distal end of which opens into the pharynx. Air is admitted to and expelled from the middle ear, thus equalizing the inner and outer sides of the membrana tympani. Any ordinary musical drum has also a hole, for the air to enter, and likewise equalize the pressure of the drum heads, or else false sounds result. So then does the eustachian tube act, as an air tube. It is about 1½ inches long, extending downward, forward and inward, and ending in a projection found in the pharynx, near the floor of the nasal fossa. Its upper half is bony, its lower is cartilagenous, and its lining is mucous membrane.

The outer wall is membranous; fibrous and broad, and is attached to the bony rim in the temporal bone. This is the *membrana tympani,* and its inner side is lined with mucosa and its outer with thin skin; it is tight in all directions except high up; there it is slightly flaccid.

The membrane is not flat, but is irregular, sloping downward and inward markedly, and the malleus is attached to it.

The inner wall of the tympanum is very uneven. There is a protrusion there for the turn of the cochlea, and below this is a round hole, the *fenestra rotunda,* which is closed by a fibrous membrane; this is the second head to the drum. Higher still is a *fenestra ovalis,* also stopped with fibrous membrane, to which is attached a bone, called the *stapes* Above this is a ridge, marking the situation of the facial nerve.

In the rear, and high up, the drum communicates with a series of irregular and connected cavities, found in the mastoid portion of the temporal bone. They are the *mastoid cells;* the largest one is called the *antrum.* These cavities are lined with mucous membrane and filled with air. They frequently become inflamed from irritation of the middle ear

and then have to be opened and cureted out clean, and dressed accordingly.

The Internal Ear, or Labyrinth, is an irregular sac, lined with a highly sensitive membrane, and filled with fluid, in which are hard particles. It is a membranous labyrinth, found in the petrous portion of the temporal bone. It does not completely fill the cavity in this bone, but is surrounded by a space filled with *perilymph.*

The *utricle,* an irregular sac; the *semi-circular canals,* superior, posterior and external; *the saccula; the canal of the cochlea;* the epithelial cells lining these canals and secreting these fluids, the ear stones and the rods of corti, with numerous other structures, minute in character, yet highly necessary to completely finish the hearing apparatus, are the intrinsic parts of the internal ear. The auditory nerve and artery enter and supply these various delicate structures at the internal auditory meatus. It is a soft nerve and readily receives impressions of sound.

The vestibule of the internal ear is supposed to distinguish *voice* from musical sounds; the *semicircular canals* seem to prevent internal *echoes* or reverberations; and the *cochlea,* or snail's shell, which contains the fluid, but no membrane, seems to be the terminus of the numerous small nerves, thus forming a highly sensitive keyboard, which is in close touch with the brain.

Nature has well protected these intricate organs of hearing which are found internally, by the twisting tortuous entrance, and the stony hardness of the bone surrounding the delicate membranes, etc. But external parts are liable to dangers from foreign bodies as previously stated, to cold, diseases, drafts as in car riding, with a crack of the window up near the ear, steel probes for removing wax, and numerous other serious dangers, not proper to mention in this book.

THE NOSE.

Smell and the Nose. The sense of smell is located in the delicate mucous membrane found lining the interior of the nose. The nose is more than the external visible por-

tion. Like the ear, its internal and more delicate parts are found high up and away from harm's reach ordinarily.

The external portion is found to be composed of cartilage and a bony frame incomplete in front, but especially strong and well protected above, where the nasal bones are situated. These nasal bones give the real shape and beauty to the nose; if too low or too high, we refer to the "bridge" as being ugly. The nose has a peculiar curve which places the anterior nasal fossae horizontal in position, thus preventing the direct entrance of air and foreign bodies, to the interior. It is so arranged that in walking we split the current of air and it passes on both sides, leaving only an "eddy of air," which we breathe at will. Besides the bones, we find small cartilages arranged in pairs, which have an important function in preventing shock to this organ; they being extremely flexible and highly elastic structures. The septum dividing the two fossae is both bony and cartilagenous. It runs the whole length of the fossae. Muscles move these external parts.

The nasal fossae are two in number, found between the anterior and posterior nasal fossae or openings.

They are high and narrow cavities, being narrowest in the centre and broadest in front and behind, and above and below. They have peculiarly twisted bones called turbinated, three in number, on each side of the nasal fossae, and under each turbinated bone we find openings, from the different cells in that region, the lowest opening coming from the eye, or lachrymal duct. That is why we "sniff" after crying, or inhaling pepper or getting a cinder in the eye, the hypersecretion goes down into the nose; through this intimate connection between the nose and eye, any inflammation in one could easily travel to, and infect the other, just as an inflammation can travel from the throat to the ear by means of the Eustachian tube. We must, then, remember the intimate relation and connection of all these special senses, even in disease as well as in ordinary functions. Each *assists* the other in *health;* but each *retards* the other in *disease.*

These turbinated or scroll-like bones are covered with highly erectile and vascular tissue, especially the inferior tur-

binated, which acts as a small *furnace* to temper the cold air and dampness which comes from without; also dust, and minute foreign bodies and gases enter, and stick to these inferior turbinated and moist bones. If the vibrissae or small hairs guarding the nasal entrance fail to catch or lodge these small particles, the turbinated bones seem to be able to check their progress. That is why the nose is o full of dust and cinders after traveling on a train. The mucous membrane of the nose is of three varieties; near the orifice, it is so intimately blended with the infolding of the skin that we call it squamous epithelium; further inside and all over the inferior and lower one-third of the walls, it is columnar-ciliated epithelium, because this is the beginning of the real air passage, and these are the little sweepers; and the upper two-thirds of the nasal fossa are lined with columnar epithelium, these are long and mixed with protoplasm and receive the special nerve endings of our special sense organ called the

Olfactory or First Cranial Pair of Nerves. The lower one-third of the nose is supplied with branches of the fifth pair of cranial nerves, and they act for respiratory purposes only. But the olfactory bulbs, which are lobules in character, originate from three roots and project outward as the tract and finally end as the bulb; this bulb is located just above the roof of the nose and three rows of nerves are given off; one set goes to the upper two-thirds of the septum nasi; one to the roof of the nasal fossae, and the last, to the upper two turbinated bones. These are special nerves of smell. They are high up in the nasal fossae, and that is why we *sniff* things high up into the roof of the nose to detect delicate odors; it is to determine the various degrees of odors. Disease may reach the vault of the nose and destroy these delicate nerve endings, thus permanently injuring the sense of smell.

Sneezing is caused by an irritation of the lower nerve-ending, or the respiratory portion; generally a piece of mucus, cinder or other substance causes this, and it is a quick action of the diaphragm forcing the air violently out through the nose, and usually dislodging the intruder and irritant.

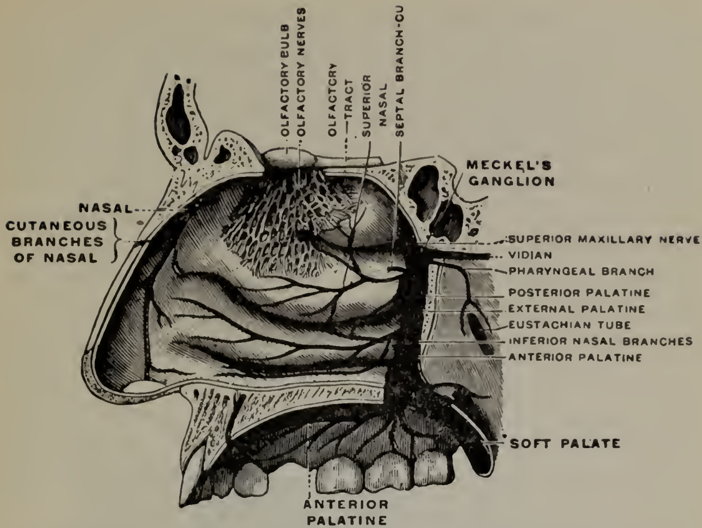

FIG. 77—Outer wall of nose, showing olfactory nerves and nerves of common sensation. (Testut.)

The termination of the olfactory nerves is peculiar. They are not protected like other nerve endings, but end directly in the surface of the mucous membrane uncovered by any protection whatever; thus, they come in contact direct, with the odors brought in by the respiratory action. The whole nasal lining is kept moist and flexible by mucous secretions of the glands found therein; but for these, the interior of the nose would be dry, hard and extremely insensitive to odors, air, and irritants generally. Grazing animals and others which root, have an abundant flow of mucus from the nose while holding the nose close to the ground and inhaling dust, fine dry grass, etc. Birds, too, have a special abundance of secretion from the head and air passages, because they respire much more actively than humans do.

Gases and volatiles generally which have or have not odors, can be detected by this special sense of smell. Solids are detected by the sense of touch and sight, and the latter also tells us somewhat the shape of objects. Taste teaches us the important factors of fluids and semifluids. So smell is highly necessary in detecting the presence of gases, etc. Substances with odors, disseminate them in an invisible

state. The nostrils, then, are on guard continuously, and the odor often prevents our accepting foods which may otherwise be perfect as far as other senses are concerned. Odors should not generally be advocated in the sick room; fresh air is the best odor to be found. Many drugs have irritating and injurious effects upon the mucous membrane of the nose. This sense should be trained to detect foul odors about the house, yard and in the pack rooms. Musty odors should be "aired away" by letting in good, fresh air and sunlight. Smell aids us in the selection of proper food, as all of our senses do. Each assists the other, and thus facilitates our rapid selection and digestion of our meals. It also greatly protects the body against bad breathing or inhalation of injurious gases. They are stationed as guards at the entrance of the air and examines the draft, and quickly passes judgment.

Certain animals and fishes have this function developed to a remarkable degree. It is said that the olfactory bulb in some, is larger than the anterior lobes of the cerebrum. The hound has an immense olfactory lobe, and it is this power which enables us to hunt the more timid and cunning animals of the woods. They scent their trail, and, nose to the ground, hunt them from their hiding places. The lion scents its prey from a great distance, but the sheep and deer only seem to have this sense developed especially against their ordinary enemies. Savages have a keener sense of smell than we generally. Humboldt states that the natives of Peru can by it, distinguish in the dark, between persons of different races. Some blind girl in Boston could detect the child from the adult; the male from the female, and the black from the white at a distance of three feet or more. One of our best pilots was a blind man who got his bearings from the *taste* of the bottom which clung to the lead used.

THE TONGUE.

The Taste Organ is the tongue; yet the tongue has other important functions. It is most essential for articulation; assists materially in mastication and deglutition; and it also possesses to a marked degree the tactile sense.

The tongue is a muscular organ, covered with a mucous membrane, extremely mobile, with a base, root, apex, dorsum and lateral borders. Its muscles are intrinsic and extrinsic, and with the mucoso, blood vessels, nerves and lymphatics, are arranged in pairs; the two halves of the tongue are separated by a central raphae. Each half has its independent nerve and blood supply; so that the removal of a tumor from one half will not be apt to injure the other half. In rest or repose, the tongue completely fills the mouth cavity; only when contracted, as in talking, etc., does it seem

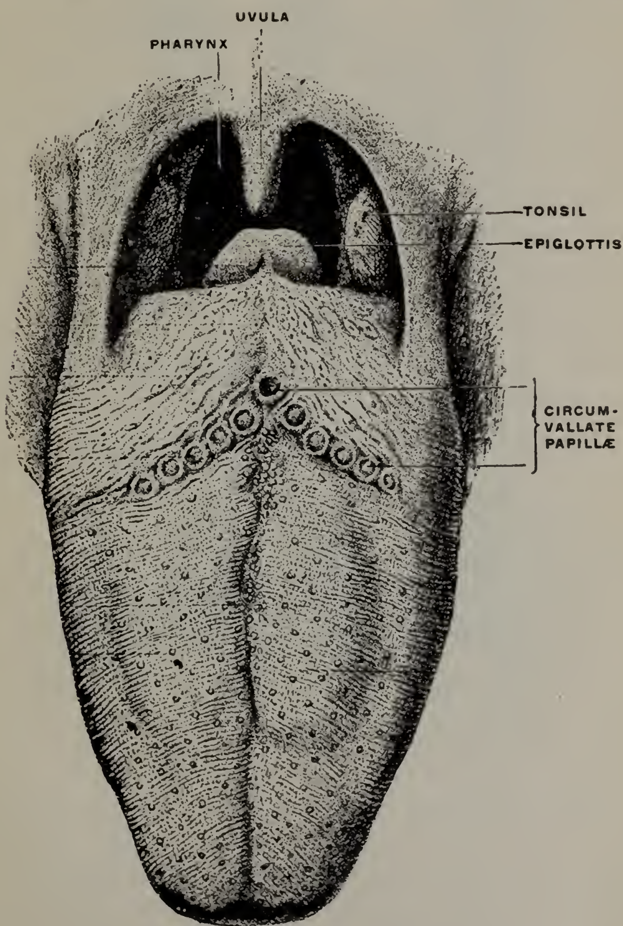

FIG. 78—Dorsal surface of the tongue. (Testut.)

to only partly fill the cavity. Its root holds it firmly to the hyoid bone. We find its dorsum or upper surface covered with small eminences called *papillae.* These are similar to those found on the tongue of a cat, which you can readily feel when it licks your finger. On a calve's, dog's and tiger's tongue, they are especially developed. A tame tiger has been known to draw the blood by kindly licking its master's hand. In carnivora, they are highly developed for the removal of ligaments, tendons, etc., of bone. On the human tongue they are of three kinds, differing in size and location, as well as function.

The Circumvallate papillae are the largest and the least numerous. They are found at the base of the tongue, arranged in the form of a V with the apex pointing toward the throat. They are from 8 to 12 in number, with the largest one in the apex. In form, they are elevations of mucous membrane, covered with a stratified epithelium similar to that of the skin. They are broader at the top, and with a trench around their bases, being a prolongation of the corium of the mucous membrane. At their summits many secondary papillae project. In the lateral surface of the papilla, found occupying the thickness of the epithelium, are numerous flask-shaped structures called *taste buds.*

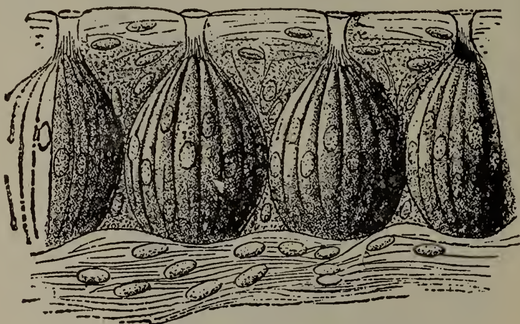

FIG. 79.—Taste-buds. (After Engleman.)

These are composed of trenches and walls surrounding these trenches, and many taste buds empty into these trenches, where solutions may readily be brought into intimate relation with the taste buds. Hence their name, "walled-around" papillae.

The Fungiform (mushroom-shaped) *Papillae* are knob-like bodies resting upon pedicles or stocks, and upon the rounded surface of which are many secondary papillae. Taste buds are also found in the fungiform papillae, but not very numerous. These papillae are found over the middle and anterior upper surface of the dorsum of the tongue, and are extremely red in color.

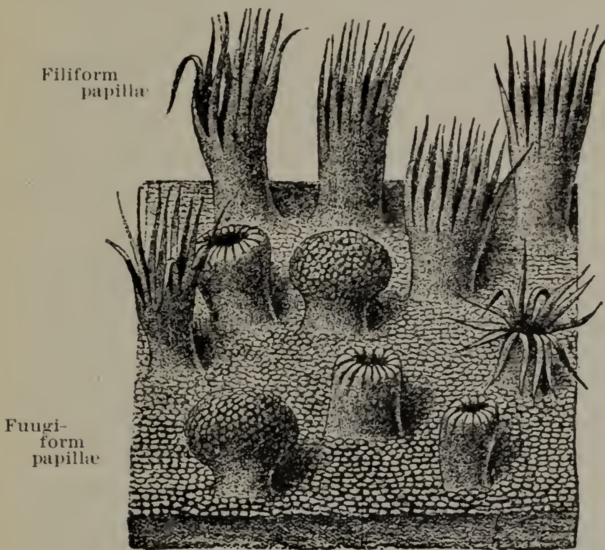

FIG. 80

The Filiform (thread-shaped) *Papillae* are most numerous and smaller than the others, and are found scattered over the dorsum of the tongue, except near the base. They are conical eminences covered by a dense epithelium drawn out into long, tapering threads, or horny points. These are the specially developed papillae which make the tongue rough.

All these different papillae have ample nerve supply. The glossopharyngeal being the special taste nerve; supplies the posterior one-third of the mucous membrane; the lingual supplies the remainder.

Many taste buds are found behind the papillae and near the epiglottis; also numbers of them are found on the hard palate, anterior surface of the soft palate and the lower ante-

rior parts of the fauces, which are pillars of muscular ribbons enclosing the tonsils and bounding laterally the fauces.

The tongue in many cases is the index of the condition of the digestive organs, especially the stomach. Derange it, and the tongue becomes coated white or yellowish, composed of mucus, epithelial cells and bacteria; these, accompanied with a "bad taste" in the mouth. The whole alimentary canal is closely allied to the tongue and other parts in its tract; they are dependent and closely related. The child's tongue is a bright red and little "fur;" in adult life the tongue is less red, except at the tip and borders. A bright red glistening tongue indicates fever and disease of some kind. A dry tongue will not taste substances; wipe it dry and place a crystal of sugar on it; no taste sensation will be felt till the exuding moisture has dissolved some of the sugar.

Tastes generally are divided into sweet, bitter, acid and saline. The intellect dictates their value; and ordinarily they are of small value individually, as far as protecting us against the quality of food is concerned, yet they do aid us in the selection of foods. Ordinary *flavors* are really *smells,* which odors reach the nose and we feel the pungency of the drug only. So the tactile sense of the tongue may fool us.

People usually taste sweets and sours at the tip of the tongue or near there; while bitters and salts are more readily tasted at the back of the tongue. Sugar and lemon taken together, create a most peculiar phenomenon chemically, which is still open for an explanation.

Solids, then, like sand, on the tongue, are insoluble and hence tasteless. In sickness, the coating on the tongue prevents the taste buds from acting; if at all, things "taste bad."

Bitter things if taken, affect the muscles through the ninth pair of nerves, and hence the action is down the throat, we swallow it, but may be nauseated; in taking intensely *sour* things we affect the muscles through the fifth and seventh pair of nerves, and hence the irregular distortions of the expression, painfully or ludicrously present.

Taste is confused and very closely allied with touch, smell, temperature, pain; and may thus be confounded with them singly or collectively. Alum may be properly astringent

in taste, yet it is more feeling than taste. Smooth, mealy, oily and watery tastes are tactile in character. Burning pungents are painful, from touch, not from taste. Mint cools the taste buds and thus temperature and not taste is responsible for that knowledge.

Coffee, garlic, etc., have a very feeble taste, but an extremely strong odor; smell, then, informs us. Hold the nose and you can only with difficulty distinguish between these substances. Sight, too, assists taste. Close the eyes and food generally is somewhat insipid. So also if a man smokes a pipe in the dark he cannot tell whether it is lighted or not by the taste. Hence if about to take a bad dose, close the nose and shut the eyes. The taste organs do help, however, in the selection of foods, and are placed on guard at the entrance.

Education of Taste is an expert schooling. Foods which gratify the taste are usually wholesome, and vice versa. Late in life, after these senses have become dulled by use, they become insufficient guides. Children prefer plain food, and should have them preferably. The Esquimaux prefer the rank smell of whale oil; it is food well suited for their icy climate. We develop a liking also for such foods if traveling in that region. Abyssinians eat raw flesh, which is flavored excellently for them; we eat it only as a medicine. Oysters taste delicious to us, while to others they are nauseating and disgusting. Hence, some seek certain foods; others despise the same foods. There are professional "tasters" of tea and wine, etc.

Alcohol is an enemy, by causing hardening and drying, to all the special senses.

Vision is the most susceptible of all the special senses to the benumbing and poisonous influences of alcoholic drink. So also with the use of tobacco. We even have a blindness called tobacco amaurosis. Tobacco may injure permanently the optic nerve, and there is only one relief, that is to *completely* abstain from its use. Hearing, too, may be seriously injured by the excessive use of tobacco and strong coffee. Opium will destroy the delicate sensations both of vision and of hearing, and often of taste, if persisted in.

Alcohol injures color perception, and as a result we have color blindness, unless we totally abandon alcohol. Pilots, engineers, navigators, captains, etc., may gradually become color blind from its too free use. They should not be allowed its use. Hearing and taste, also touch, are seriously impaired by excessive alcoholic drinking, especially wood alcohol, as that is far worse than serial or grain alcohol.

Drawing, fine scroll work, the use of delicate tools, penmanship, etc., needs an absolutely steady hand, and alcohol tends to make it unsteady; hence, many men lose their positions through alcoholic drink. Palsy is a common result of excess and long use of alcohol.

Delirium Tremens, or "the horrors," are final states of the drunkard's folly in undue and continuous drinking. These poor misguided fools see imaginary "snakes," "hideous animals and horrible sights" from the effects of the fevers brought on by alcoholic drinking. They have jumped from high windows to escape these purely imaginary fiends, as they say, chasing them. It is simply alcohol, acting too vigorously upon the brain centres.

Voice in Man and Animals. Man, in common with the nobler animals, possesses the power of uttering articulate sounds, which are used for expressions of communications. This, in man, is considered as his *voice;* in an animal, it is considered its *cry*. The bird's song is an *active* respiratory function, which results really in its *cry* so-called. Animals usually produce these sounds by their breathing apparatus. Insects, like the *mosquito,* produce their sounds by the extremely rapid vibrations of their *wings* in the act of flight; *crickets,* by the rubbing together of *hard portions* of the external covering of the *body;* and marine animals are almost noiseless, except the toad, grumbler and a few others, which make a queer and grating noise, as the sea lion, etc.

We saw in the anatomy of the larynx that it was considered the voice box or music box of the human body. The structures which produce these varied sounds are the vocal cords and incidentally the tongue, lips and soft palate.

The Vocal Cords are two in number on each side; *above,* one on each side, are the *false vocal cords; below,* one on

each side, are the *true vocal* cords; in between these two pairs of cords is a space, called the *ventricle of the larynx.* These two vocal bands are elastic tissue reaching from the inner angle (or vocal angle) of the base of each arytenoid cartilage to the receding angle of the inner side of the thyroid cartilage, where the sides of the V-shaped opening unite; hence they meet in front, but are separated at their posterior ends. These cords are bare strings, like those of a violin, but covered over with the lining mucous membrane of the larynx; a slit, a small space is left between them which is called the *glottis.* On each side of these true or inferior cords are *projecting pads* or cushions, (on each side of the glottis), which are set in vibration during phonation, or voice formation. If *open,* and *relaxed,* these cords produce *no sound;* only when *narrow and tense* is *voice* produced. Previous to this chapter, we found that below the true vocal cords, the epithelium was *ciliated,* or hair-like, which keep moving, like wheat straw in the field, upward toward the throat. All these movements are influenced and controlled by the muscles through the nervous impulses, which impulses come through the superior and inferior laryngeal nerves, branches of the Vagus or tenth pair of cranial nerves. The blood supplying these parts comes from the superior and inferior thyroid arteries, branches of the external carotid and thyroid axis of the subclavian arteries, respectively.

THE DIFFERENT POSITIONS OF THE VOCAL CORDS

FIG. 81.—*A*, The position during inspiration. *B*, In the formation of low notes. *C*, In the formation of high notes.

The epiglottis protects this glottis or slit, but if the epiglottis is removed surgically, the folds around the glottis enlarge and then prevent particles from passing into the larynx. Nature, indeed, performs some interesting feats.

The False Vocal Cords are not important in voice formation at all. They are comparatively fixed and inflexible cords.

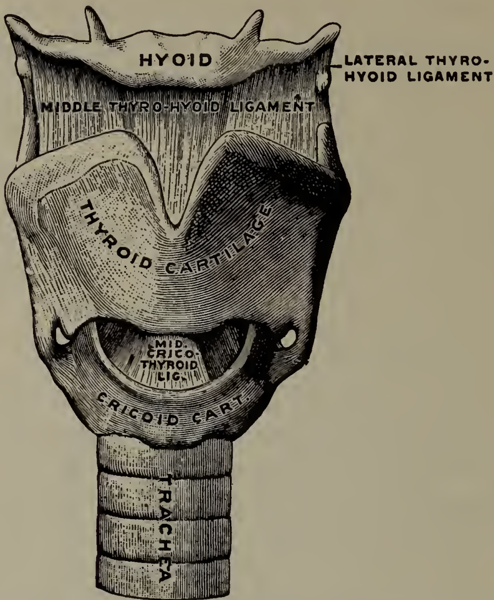

FIG. 82.—Laryngeal cartilages and ligaments from in front. (Testut.)

Voice is formed only in *forced expiration,* and when the cords are made extremely *tense* and brought *close together;* not being more than 1-100 of an inch separated; so that as the air is passing through them, it causes the cords to rapidly *vibrate,* similar to the strings of an instrument. Thus all sounds are formed. Tone or pitch depends, upon the activity of the lungs, etc., in expelling the air. High notes require an extremely narrow slit of the true cords; low notes require wider space and slower vibrations. The shape of the chest and trachea walls assist in the resonance of voice; so also do the tongue, soft palate, teeth and lips assist. There is a case on record, however, of a woman losing her whole tongue and part of the soft palate, and still being able to talk and sing. Man has a strong and heavy voice; woman a soft and high one. In childhood, both male and female have soft soprano voices; at 14 the voice changes considerably, owing to the rapid growth of the larynx; it may be a high tenor in one sentence, and a deep base in another for the same reason

as above. In this stage, the larynx almost doubles in size in one year, hence the cords grow stronger, thicker and coarser; he feels and talks like a *man*.

Voice usually has a range of about two octaves. Some celebrated vocalists have a greater range. Madame Rose had three full octaves. "Purity" of tone, means that the organs have, through careful training, become exact in tension and their vibrations are precise and true. This kind of voice can be heard distinctly above a full choir; purity, rendering it distinct and clear.

Vocal Exercise is highly necessary in voice culture. Reading aloud, recitation, speaking, singing, etc., require the varied activity of most of the chest muscles to a degree of which few are conscious, unless special attention is called to the contraction and relaxation of the muscles. We find also these exercises stimulating to healthy action, the abdominal muscles, and diaphragm; and incidentally the intestines are also stimulated to a healthy action, which quickens digestion, enhances discharges of effete material and generally causes an invigorating feeling over the whole body.

Ventriloquism is an unnatural management of the voice, so as to produce sounds or to appear to produce sounds, which issue from the trees, chimneys, animals, etc. The word itself means "speaking from the belly." The Romans and Greeks used this mode of voice formation, and may have used the same power in causing the sacred trees, and the oracles at Delphi to, seemingly, speak. The ventriloquist seems to "throw his voice" and imitate other sounds. He must, therefore, be an excellent mimicry.

Conversation is generally greatly improved by vocal exercises. It gets you out of that slow, lazy drawling tone so objectionable to the real cultured conversationalist. Absentmindedness, listnessness, and many other defects are improved rapidly by the vocal culture of good masters. Clear speech usually means a clear mind.

Vowels are compound musical tones, produced only in the larynx, said some vocal teacher.

Consonants are produced by the vocal cords and also by the blast or forced expiratory current of air passing through the mouth.

APPENDIX.

Death is the ending of life. But for the intervention of death, we might shrivel and dwindle away till we got smaller and smaller and at last reached the point where we first began, viz: the minute cell, too small to see with the naked eye. At the age of 40 in woman and 45 in man, the tissues generally begin to shrink and lose their power of withstanding fatigue. Bacon said, "It is as natural to die as it is to be born." Death approaching, dulls the sensibilities of the whole body structure, but some functions are retained longer than others. Some retain their mental factors and functions up to the very end of life; others become unconscious for many days before death comes. It is difficult to say just when death does occur. Some say it is present before the heart ceases to beat.

Life has its duties, each of which is performed, or should be, to the full capacity of the many different organs. These organs and talents within them, should be trained, and utilized to the fullest capability.

The Reproductive Organs. In the male, they are two in number, and are found in the scrotum. They are the *testicles;* other copulative organs are associated with them in reproducing, but these small organs are the special factors in secreting the reproductive spermatozoa or semen. In the female, we also find two similar organs, found in the broad ligaments of the woman, and these are called *ovaries.* We also find other organs of infinite importance associated with these ovaries in reproduction.

This subject is not necessary, except in a special medical course, given by the specialist in that particular subject.

GLOSSARY.

Ab-do'men (Latin *abdo,* to conceal). The largest cavity of the body, containing the liver, stomach, intestines, etc.; the belly.

Ab-sor'bents (L. *ab* and *sorbeo,* to suck up). The vessels which take part in the process of absorption.

Ab-sorp'tion. The process of sucking up fluids by means of an animal membrane.

Ac-com-mo-da'tion of the Eye. The alteration in the shape of the crystalline lens, which accommodates or adjusts the eye for near and demote vision.

Al-bu'men, or Albumin (L. *albus,* white). An animal substance resembling white of egg.

Al'i-ment (L. *alo,* to nourish). That which affords nourishment; food.

Al-i-ment'ary Ca-nal (from *aliment*). A long tube in which the food is digested, or prepared for reception into the system.

An-aes-thet'ics (Greek *an,* without, *aisthesia,* feeling). Those medicinal agents which prevent the feeling of pain, such as chloroform, laughing gas, etc.

A-or'ta (Gr. *aorteomai,* to be lifted up). The largest artery of the body, and main trunk of all the arteries. It arises from the left ventricle of the heart. The name was first applied to the two large branches of the trachea, which appear to be lifted up by the heart.

A'que-ous Humor (L. *aqua,* water). A few drops of watery colorless fluid occupying the space between the cornea and crystalline lens.

A-rach'noid Mem'brane (Gr. *arachne,* a cobweb, and *eidos,* like). An extremely thin covering of the brain and spinal cord. It lies between the *dura mater* and the *pia mater.*

Ar'bor Vi'tae (L.) Literally, "the tree of life;" a name given to the peculiar appearance presented by a section of the cerebellum.

Ar'ter-y (Gr. *aer,* air, and *terein,* to contain). A vessel by which blood is conveyed away from the heart. It was supposed by the ancients to contain air; hence, the name.

Ar-tic-u-la'tion (L. *articulo,* to form a joint). The more r less movable union of bones, etc.; a joint.

A-ryt'e-noid Car'ti-la-ges (Gr. *arutaina,* a pitcher). Two small cartilages of the larynx, resembling the mouth of a pitcher.

As-sim-i-la'tion (L. *ad,* to, and *similis,* like). The conversion of food into living tissue.

Au'ri-cle (L. *auris,* the earl). A cavity of the heart.

Bel-la-don'na (It. beautiful lady). A vegetable narcotic poison. It has the property of enlarging the pupil, and thus increasing the brilliancy of the eye; so called from its use by Italian ladies.

Bi-cus'pid (L. *bi,* two, and *cuspis,* prominence). The name of the fourth and fifth teeth on each side of the jaw; possessing two prominences.

Bile. The gall, or peculiar secretion of the liver; a viscid, yellowish fluid, and very bitter to the taste.

Bronch'i (Gr. *brogchos,* the windpipe). The two first divisions or branches of the trachea; one enters each lung.

Bronch'i-al Tubes. The smaller branches of the trachea within the substance of the lungs, terminating in the air-cells.

Bronch-i'tis (from *bronchia,* and *itis,* a suffix signifying inflammation). An inflammation of the larger bronchial tubes; a "cold" affecting the lungs.

Cal-ca're-ous (L. *calx,* lime). Containing lime.

Ca-nal (L.) In the body, any tube or passage.

Ca-nine' (L. *canis,* a dog). Name given to the third tooth on each side of the jaw; in the upper jaw it is also known as the eye-tooth, pointed like the tusks of a dog.

Cap'il-la-ry (L. *capil'lus,* a hair, *capilla'ris,* hair-like). The name of the extremely minute blood-vessels which connect the arteries with the veins.

Car'bon Diox-ide (CO_2). Chemical name for carbonic acid gas.

Car-bon'ic A'cid. The gas which is present in the air expired from the lungs; a waste product of the animal kingdom, and a food of the vegetable kingdom.

Car'di-ac (Gr. *cardia,* the heart). The cardiac orifice of the stomach is the upper one, and is near the heart; hence its name.

Car-niv'o-rous (L. *ca'ro,* flesh, and *vo'ro,* to devour). Subsisting upon flesh.

Car'ti-lage. A solid but flexible material, forming a part of the joints, air-passages, nostrils, etc.; gristle.

Ca'se-ine (L. *ca'seus,* cheese). The albuminoid substance of milk; it forms the basis of cheese.

Cer-e-bel'lum (diminutive for *cer'ebrum,* the brain). The little brain, situated beneath the posterior third of the cerebrum.

Cer'e-brum (L.) The brain proper, occupying the entire upper portion of the skull. It is nearly divided into two equal parts, called "hemispheres," by a cleft extending from before backward.

Cho'roid (Gr. *chorion,* a membrane or covering). The middle tunic or coat of the eyeball.

Chyle (Gr. *chulos,* juice). The milk-like fluid formed by the digestion of fatty articles of food in the intestines.

Chyme (Gr. *chumos,* juice). The pulpy liquid formed by digestion within the stomach.

Cil'i-a (pl. of *cil'i-um,* an eyelash). Minute, vibratile, hair-like processes found upon the cells of the air-passages, and other parts that are habitually moist.

CIR-CU-LA'TION (L. *cir'culus,* a ring). The circuit, or course of the blood through the blood-vessels of the body, from the heart to the arteries, through the capillaries into the veins and from the veins back to the heart.

CO-AG-U-LA'TION (L. *coag'ulo,* to curdle). Applied to the process by which the blood clots or solidifies.

COCH'LE-A (L. *coch'lea,* a snail-shell). The spiral cavity of the internal ear.

CONCH'A (Gr. *konche,* a mussel-shell). The external shell-shaped portion of the external ear.

CON-JUNC-TI'VA (L. *con* and *jun'go,* to join together). A thin layer of mucous membrane which lines the eyelids and covers the front of the eyeball, thus joining the latter to the lids.

CON-VO-LU'TIONS (L. *con.* and *vol'vo,* to roll together). The tortuous foldings of the external surface of the brain.

CON-VUL'SION (L. *convel'lo,* to pull together). A more or less violent agitation of the limbs or body.

COR'NE-A (L. *cor'nu,* a horn). The transparent, horn-like substance which covers the anterior fifth of the eyeball.

COR'PUS-CLES, BLOOD (L. dim. of *cor'pus,* a body). The small biconcave disks which give to the blood its red color; the *white* corpuscles are globular and larger.

COS-MET'IC (Gr. *kosmeo,* to adorn). Beautifying.

CRA'NI-AL (L. *cra'nium,* the skull). Pertaining to the skull. The nerves which arise from the brain are called cranial nerves.

CRI'COID (Gr. *kri'kos,* a ring). A cartilage of the larynx resembling a seal-ring in shape.

CRYS'TAL-LINE LENS (L. *crystal'lum,* a crystal). One of the so-called humors of the eye; a double convex body situated in the front part of the eyeball.

CU'TI-CLE (L. dim. of *cu'tis,* the skin). The scarf-skin; also called the *epider'mis.*

CU'TIS (L., skin or hide). The true skin, lying beneath the cuticle; also called the *der'mis.*

DI'A-PHRAGM (Gr. *diaphrasso,* to divide by a partition). A large, thin muscle which separates the cavity of the chest from the abdomen; a muscle of respiration.

DIF-FU'SION OF GASES. The power of gases to become intimately mingled, without reference to the force of gravity.

DUCT (L. *du'co,* to lead). A narrow tube; the *thoracic duct* is the main trunk of the absorbent vessels.

DU-O-DE'NUM (L. *duode'ni,* twelve). The first division of the small intestines, about twelve fingers-breadth long.

DU'RA MA'TER (L.) Literally, the hard mother; the tough membrane which envelops the brain.

DYS-PEP'SI-A (Gr. *dus,* difficult, and *pepto,* to digest). Difficult or painful digestion; a disordered condition of the stomach.

E-MUL'SION (L. *emul'geo,* to milk). Oil in a finely divided state suspended in water.

EN-AM'EL (Fr. *email*). The dense material which covers the crown of the tooth.

ENDOCARDIUM (Gr. *endo,* within, and *kardia,* the heart). The lining membrane of the heart.

EP-I-GLOT'TIS (Gr. *epi,* upon, and *glottis,* the entrance to the wind-pipe). A leaf-shaped piece of cartilage which covers the top of the larynx during the act of swallowing.

EX-CRE'TION (L. *excer'no,* to separate). The separation from the blood of the waste particles of the body; also the materials excreted.

EX-PI-RA'TION (L. *expi'ro,* to breathe out). The act of forcing air out of the lungs.

FI'BRINE (L. *fi'bra,* a fibre). An albuminoid substance found in the blood; in coagulating it assumes a fibrous form.

FOL'LI-CLE (L. dim. of *fol'lis,* a bag). A little pouch or depression in a membrane; it has generally a secretory function.

GAN'GLI-ON (Gr. *ganglion,* a knot). A knot-like swelling in the course of a nerve; a smaller nerve-centre.

GAS'TRIC (Gr. *gaster,* stomach). Pertaining to the stomach.

GLAND (L. *glans,* an acorn). An organ consisting of follicles and ducts, with numerous blood-vessels interwoven; it separates some particular fluid from the blood.

GLU'TEN (L.) Literally, glue; the glutinous albuminoid ingredient of wheat.

GRAN'ULE (L. dim. of *gra'num,* a grain). A little grain; a microscopic object.

GUS-TA'TION (L. *gusto,* to taste). The sense of taste.

GUS'TA-TO-RY NERVE. The nerve of taste supplying the front part of the tongue, a branch of the "fifth" pair.

HEM'OR-RHAGE (Gr. *hai'ma,* blood, and *regnumi,* to burst). Bleeding, or the loss of blood.

HEM-I-PLE'GIA (Gr. *hemisus,* half, and *plesso,* to strike). Paralysis, or loss of power, affecting one side of the body.

HEM'I-SPHERES (Gr. *sphaira,* a sphere). Half a sphere, the lateral halves of the cerebrum, or brain proper.

HE-PAT'IC (Gr. *hepar,* the liver). Pertaining to the liver.

HER-BIV'O-ROUS (L. *her'ba,* an herb, and *vo'ro,* to devour). Applied to animals that subsist upon vegetable food.

HU'MOR (L.) Moisture; the humors are transparent contents of the eyeball.

HY'GI-ENE (Gr. *hugieia,* health). The art of preserving health and preventing disease.

HY'PER-O'PI-A. Abbreviated from HY'PER-MET-RO'PI-A (Gr. *huper,* beyond, *metron,* the measure, and *ops,* the eye). A defect of vision dependent upon a too short eyeball; so called because the rays of light are brought to a focus at a point behind the retina; the true "far sight."

IN-CI'SOR (L. *inci'do,* to cut). Applied to the four front teeth of both jaws, which have sharp cutting edges.

IN'CUS (L.) An anvil; the name of one of the bones of the middle ear.

IN-SPI-RA'TION (L. *in,* and *spi'ro,* to breathe). The act of drawing in the breath.

IN-TEG'U-MENT (L. *in,* and *te'go,* to cover). The skin, or outer covering of the body.

IN-TES'TINE (L. *in'tus,* within). The part of the alimentary canal which is continuous with the lower end of the stomach; also called the intestines, or the bowels.

I'RIS (L. *i'ris,* the rainbow). The thin muscular ring which lies between the cornea and the crystalline lens, and which gives the eye its brown, blue, or other color.

JU'GU-LAR (L. *ju'gulum,* the throat). The name of the large veins which run along the front of the neck.

LAB'Y-RINTH (Gr. *laburin'thos,* a building with many winding passages). The very tortuous cavity of the inner ear, comprising the vestibule, semi-circular canals, and the cochlea.

LACH'RY-MAL APPARATUS (L. *lach'ryma,* a tear). The organs for forming and conveying away the *tears.*

LAC'TE-ALS (L. *lac, lac'tis,* milk). The absorbent vessels of the small intestines; during digestion they are filled with chyle, which has a milky appearance.

LAR'YNX (Gr.) The cartilaginous tube situated at the top of the windpipe, or trachea; the organ of the voice.

LENS (L.) Literally, a lentil; a piece of transparent glass or other substance so shaped as either to converge or disperse the rays of light.

LIG'A-MENT (L. *li'go,* to bind). A strong, fibrous material binding bones or other solid parts together; it is especially necessary to give strength to joints.

LIG'A-TURE. A thread of silk or other material used in tying around an artery.

LYMPH (L. *lym-pha,* spring-water). The colorless, watery fluid conveyed by the lymphatic vessels.

LYM-PHAT'IC VESSELS. A system of absorbent vessels.

MAL'LE-US (L.) Literally, the mallet; one of the small bones of the middle ear.

MAR'ROW. The soft, fatty substance contained in the central cavities of the bones; the spinal marrow, however, is composed of nervous tissue.

MAS-TI-CA'TION (L. *mas'tico,* to chew). The act of cutting and grinding the food to pieces by means of the teeth.

ME-DUL'LA OB-LON-GA'TA. The "oblong marrow," or nervous cord, which is continuous with the spinal cord within the skull.

MEM-BRA'NA TYM'PAN-I (L.) Literally, the membrane of the drum; a delicate partition separating the outer from the middle ear; it is sometimes incorrectly called the drum of the ear.

MEM'BRANE. A thin layer of tissue serving to cover some part of the body.

MI'CRO-SCOPE (Gr. *mikros,* small, and *skopeo,* to look at). An optical instrument which assists in the examination of minute objects.

MO'LAR (L. *mo'la,* a mill). The name applied to the three back teeth of each side of the jaw; the grinders, or mill-like teeth.

MO'TOR (L. *mo'veo, mo'tum,* to move). Causing motion; the name of those nerves which conduct to the muscles the stimulus which causes them to contract.

MU'COUS MEM'BRANE. The thin layer of tissue which covers those internal cavities or passages which communicate with the external air.

MU'CUS. The glairy fluid which is secreted by mucous membranes, and which serves to keep them in a moist condition.

MY-O'PI-A (Gr. *muo,* to contract, and *ops,* the eye). A defect of vision dependent upon an eyeball that is too long, rendering distant objects indistinct; near sight.

NA'SAL (L. *na'sus,* the nose). Pertaining to the nose; the *nasal cavities* contain the distribution of the special nerve of smell.

NERVE (Gr. *neuron,* a cord or string). A glistening, white cord of cylindrical shape, connecting the brain or spinal cord with some other organ of the body.

NU-TRI'TION (L. *nu'trio,* to nourish). The processes by which the nourishment of the body is accomplished.

OE-SOPH'A-GUS (Gr.) Literally, that which carries food; the tube leading from the throat to the stomach; the gullet.

OL-FAC'TO-RY (L. *olfa'cio,* to smell). Pertaining to the sense of smell.

OP'TIC (Gr. *opsomai,* to see). Pertaining to the sense of sight.

OR'BIT (L. *or'bis,* the socket). The bony socket or cavity in which the eyeball is situated.

PAN'CRE-AS (Gr. *pan,* all, and *kreas,* flesh). A long, flat gland situated near the stomach; in the lower animals the analogous organ is called the sweet-bread.

PA-PIL'LAE (L. *papil'la*). The minute prominences in which terminate the ultimate fibres of the nerves of touch and taste.

PA-TEL'LA (L. dim, of *pat'ina,* a pan). The knee-pan; a small bone.

PEL'VIS (L.) Literally a basin; the bony cavity at the lower part of the trunk.

PEP'SIN (Gr. *pepto,* to digest). The organic principle of the gastric juice.

PER-I-CAR'DI-UM (Gr. *peri,* and *kardia,* the heart). A porous membrane enclosing the heart, and secreting a lubricating fluid.

PER-I-STAL'TIC MOVE-MENTS (Gr. *peristello,* to contract). The slow, wave-like movements of the stomach and intestines.

PER-I-TO-NE'UM (Gr. *periteino,* to stretch around). The investing membrane of the stomach, intestines, and other abdominal organs.

PER-SPI-RA'TION (L. *perspi'ro,* to breathe through). The sweat, or watery exhalation of the skin; when visible, it is called *sensible* perspiration; when invisible, it is called *insensible* perspiration.

PE'TROUS (Gr. *petra,* a rock). The name of the hard portion of the temporal bone, in which is situated the drum of the ear and labyrinth.

PHAR'YNX (Gr. *pharugx,* the throat). The cavity between the back of the mouth and gullet.

PHYS-I-OL'O-GY (Gr. *phusis,* nature, and *logos,* a discourse). The science of the functions of living, organized beings.

PI'A MA'TER (L.) Literally, the tender mother; the innermost of the three coverings of the brain. It is thin and delicate; hence the name.

PLEU'RA (Gr., a rib). A membrane covering the lung and lining the chest. There is one for each lung.

PLEU'RI-SY. An inflammation affecting the pleura.

PNEU-MO-GAS'TRIC (Gr. *pneumon,* the lungs, and *gaster,* the stomach). The name of a nerve distributed to the lungs and stomach; it is the principal nerve of respiration.

PNEU-MO'NIA (Gr.) An inflammation affecting the air-cells of the lungs.

PORTA. Relating to the portal vein; porta, meaning gateway.

PRES-BY-O'PI-A (Gr. *presbus,* old, and *ops,* the eye). A defect of the accommodation of the eye, caused by the hardening of the crystalline lens; the "far-sight" of adults and aged persons.

PROC'ESS (L. *proce'do, proces'sus,* to proceed, to go forth). Any projection from a surface. Also, a method of performance; a procedure.

PTY'A-LIN (Gr. *ptualon,* saliva). The peculiar organic ingredient of the saliva.

PUL'MO-NA-RY (L. *pul'mo, pulmo'nis,* the lungs). Pertaining to the lungs.

PULSE (L. *pel'lo, pul'sum,* to beat). The striking of an artery against the finger, occasioned by the contraction of the heart, commonly felt at the wrist.

PU'PIL (L. *pupil'la*). The central, round opening in the iris, through which light passes into the depths of the eye.

PY-LO'RUS (L. *puloros,* a gate-keeper). The lower opening of the stomach, at the beginning of the small intestine.

RE'FLEX ACTION. An involuntary action of the nervous system, by which an external impression conducted by a sensory nerve is reflected, or converted into a motor impulse.

RES-PI-RA'TION (L. *res'piro,* to breathe frequently). The function of breathing, comprising two acts: *inspiration,* or breathing in, and *expiration,* or breathing out.

RET'I-NA (L. *re'te,* a net). The innermost of the three tunics or coats of the eyeball, being an expansion of the optic nerve.

SAC'CHA-RINE (L. *sac'charum,* sugar). Of the nature of sugar; applied to the important group of food substances which embraces the different varieties of sugar, starch and gum.

SA-LI'VA (L.) The moisture or fluids of the mouth, secreted by the salivary glands, etc.

SCLE-ROT'IC (Gr. *skleros,* hard). The tough, fibrous outer tunic of the eyeball.

SE-BA'CEOUS (L. *se'bum,* fat). Resembling fat; the name of the oily secretion by which the skin is kept flexible and soft.

SE-CRE'TION (L. *secer'no, secre'tum,* to separate). The process of separating from the blood some essential important fluid, which fluid is also called a secretion.

SEN-SI-BIL'I-TY, GENERAL. The power possessed by nearly all parts of the human body of recognizing the presence of foreign objects that come in contact with them.

SE'RUM (L.) The watery constituent of the blood, which separates from the clot during the process of coagulation.

SKEL'E-TON (Gr.) The bony framework of an animal, the different parts of which are maintained in their proper relative positions.

SPHYG'MO-GRAPH (Gr. *sphugmos,* the pulse, and *grapho,* to write). An ingenious instrument by means of which the pulse is delineated upon paper.

STA'PES (L.) Literally, a stirrup; one of the small bones of the tympanum, or middle ear, resembling somewhat a stirrup in shape.

STENSON. The duct connecting the parotid gland with the mouth.

SYM-PA-THET'IC SYSTEM OF NERVES. A double chain of nervous ganglia, connected together by numerous small nerves, situated chiefly in front of and on each side of the spinal column.

SYN-O'VI-A (Gr. *sun,* and *oon,* egg, resembling an egg). The lubricating fluid of joints, so called because it resembles the white of egg.

SYS'TO-LE (Gr. *sustello,* to contract). The contraction of the heart, by which the blood is expelled from that organ.

TAC-TILE (L. *tac'tus,* touch). Relating to the sense of touch.

TEM'PO-RAL (L. *tem'pus,* time, and *tem'pora,* the temples). Pertaining to the temples; the name of an artery; so called, because the hair begins to turn white with age in that portion of the scalp.

TEN'DON (L. *ten'do,* to stretch). The white, fibrous cord or band by which a muscle is attached to a bone; a sinew.

TET'A-NUS (Gr. *teino,* to stretch). A disease marked by persistent contractions of all or some of the voluntary muscles; those of the jaw are sometimes solely affected; the disorder is then termed locked-jaw.

THO'RAX (Gr. *thorax,* a breast-plate). The upper cavity of the trunk of the body, containing the lungs, heart, etc.; the chest.

THY'ROID (Gr. *thureos,* a shield). The largest of the cartilages of the larynx; its angular projection in the front of the neck is called "Adam's apple."

TRA'CHE-A (Gr. *trachus,* rough). The windpipe, or the largest of the air-passages; composed in part of cartilaginous rings, which render its surface rough and uneven.

TRANS-FU'SION (L. *transfun'do,* to pour from one vessel to another). The operation of injecting blood taken from one person into the veins of another; other fluids than blood are sometimes used.

TRICH-I'NA SPI-RA'LIS (L.) A minute species of parasite or worm, which infests the flesh of the hog, and which may be introduced into the human system by eating pork not thoroughly cooked.

TYM'PA-NUM (Gr. *tumpanon,* a drum). The cavity of the middle ear, resembling a drum in being closed by two membranes, and in having communication with the atmosphere.

U'RE-A (Gr.) A substance secreted from the blood by the kidneys.

U'VU-LA (L. *uva,* a grape). The small pendulous body attached to the back part of the palate.

VAS'CU-LAR (L. *vas'culum,* a little vessel). Pertaining to, or containing blood vessels.

VE'NOUS (L. *ve'na,* a vein). Pertaining to, or contained within a vein.

VEN-TI-LA'TION. The introduction of fresh air into a room or building in such a manner as to keep the air within it in a pure condition.

VEN-TRIL'O-QUISM (L. *ven'ter,* the belly, and *lo'quor,* to speak). A modification of natural speech by which the voice is made to appear to come from a distance. The ancients supposed that the voice was formed in the belly; hence the name.

VEN'TRI-CLES of the heart. The two largest cavities of the heart, situated at its apex or point.

VER'TE-BRAL COLUMN L. *ver'te-bra,* a joint). The back-bone, consisting of twenty-six separate bones, called vertebræ, firmly jointed together; also called the spinal column and spine.

VIL'LI (L. *vil'lus,* the nap of cloth). Minute thread-like projections found upon the internal surface of the small intestine, giving it a velvety appearance.

VIT'RE-OUS (L. *vi'trum,* glass). Having the appearance of glass, applied to the humor occupying the largest part of the cavity of the eyeball.

VIV-I-SEC'TION (L. *vi'vus,* alive, and *se'co,* to cut). The practice of operating upon living animals, for the purpose of studying some physiolgical process.

VOCAL CORDS. Two elastic bands or ridges situated in the larynx; they are the essential parts of the organs of the voice.

WHARTON'S DUCT. Connects the submaxillary gland with the mouth.

WIERSUNG'S DUCT. The duct connecting the pancreas with the duodenum.

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